Dairy Cattle Fertility & Sterility

HOARD'S DAIRYMAN

Dairy Cattle
Fertility & Sterility

HOARD'S DAIRYMAN

This One
RSB1-5SC-ZLBZ
Copyrighted material

Copyright © 1996 by W.D. Hoard & Sons Company

All rights reserved. No part of this book may be reproduced or used in any form or by any means, electronic or mechanical, including photocopying, recording or by any information or storage and retrieval system, without permission in writing from the publisher. Address inquiries to
W.D. Hoard & Sons Company, 28 Milwaukee Avenue West,
Fort Atkinson WI 53538 USA. FAX 414/563-7298;
e-mail Hoards @intaccess.com

ISBN 0-932147-27-5

Printed in the United States of America

Contents

Foreword 4

Chapter

1 Infertility and sterility – A multimillion dollar loss 5
2 The bull's role 7
3 The cow's reproductive tract 11
4 Reproduction – Full-time job for the dairy cow 15
5 Union of sperm and egg 22
6 Before birth – A calf begins to grow 24
7 It's calving time! 28
8 When should cows be bred? 33
9 Can we feed for fertility? 37
10 Inherited problems 44
11 Diseases of reproduction 47
12 Health of fresh cows – Impact on reproduction 54
13 Improving management 56
14 Management tips & records 61
15 Inseminating your own cows 65
16 How to deal with infertility 69
17 Controlling reproductive processes in dairy cattle 72
18 Using bulls on the farm 78

Foreword

WE ARE PLEASED to offer this newest edition of DAIRY CATTLE FERTILITY AND STERILITY. This is an important title in our dairy library, and we are fortunate to have had the talents of a number of authors in the writing and updating of several editions of this book over the past 30 years. In this time over 300,000 copies of this book have been sold.

The original writing of authors Harold D. Hafs and Louis J. Boyd provides the book's backbone. Dr. Hafs today is retired and currently acting animal science department head at Rutgers University. Dr. Boyd most recently was coordinator of contracts and grants, College of Agriculture, University of Georgia, and now has retired.

Those who have updated the book since its first printing in 1964 include Wayne D. Oxender, D.V.M., professor of large animal surgery and medicine, North Carolina State University; and Dr. J. H. Britt, associate dean of the College of Veterinary Medicine, North Carolina State University at Raleigh, along with his associate Dr. M. D. Whitacre.

We appreciate the thoroughness of this most recent updating by Ray L. Nebel, associate professor of reproductive physiology and extension specialist in reproductive management in the department of dairy science, Virginia Tech at Blacksburg; Jeffrey S. Stevenson, professor of reproductive physiology at Kansas State University; and W. S. Swecker, DVM, College of Veterinary Medicine, Virginia Tech at Blacksburg.

The book is now greatly expanded in the areas of heat detection and management; uses of milk progesterone tests; electronic heat devices; how health of fresh cows impacts reproduction; and the latest approaches and procedures for controlling reproductive processes, including heat synchronization and embryo transfer. We are grateful for the effort and expertise of those who have contributed to this book, including A.I. organizations. We hope that everyone will find this newest edition full of valuable and practical information and that FERTILITY AND STERILITY will continue to have favorable influence on dairy cattle reproduction.

HOARD'S DAIRYMAN

Chapter 1

Infertility and sterility

A multimillion dollar loss

WHEN A HIGH PRODUCING COW has to be culled for failure to breed back, the dairyman not only loses a valuable member of the herd, but also loses the opportunity to cull a less valuable, lower-producing herdmate. Infertility continues to rank as one of the major reasons for involuntary culling in dairy herds. When too large a proportion of cows are culled for infertility, the average milk yield for the herd may decline. Even today with modern veterinary medicine, reproductive failures are all too common in most dairy herds.

There are many false ideas about infertility and sterility. In the first place, sterility is not a disease in itself. Rather, it may be due to the action of **several diseases or malfunctions** working together or separately. As a result, each case must be diagnosed and treated individually according to its own symptoms.

The large number of causes complicates diagnosis and treatment, and makes sterility or infertility one of the most difficult problems for dairymen and veterinarians. Since sterility is not a disease caused by one specific agent, there is no universal cure-all.

The terms "sterility" and "infertility" will be used frequently so let's be perfectly clear about what we mean.

Sterility describes the animal that cannot reproduce.

Infertility, on the other hand, describes the animal that is neither normally fertile nor totally sterile.

A bull that produces no sperm cells is completely sterile. A "freemartin" heifer, because she was born twin to a bull, is usually sterile.

Animals such as these must be culled from the herd—a direct financial loss. But these are the easy cases. They are easy to detect and can be culled before they become too costly.

We usually think of a "normal" cow as one that conceives the first or second time she is bred. But more typically, we have cows that are somewhere between completely sterile and "normally" fertile.

These are the frustrating cows that may not be observed in estrus or must be bred several times before they settle, and,consequently, do not freshen at the desired time.

Controlling cost and increasing efficiency of production without making large capital investments are important factors for dairy producers to consider. Herd reproductive efficiency is one area of herd management that should receive increased attention. All information gathered to date suggests that maintaining a high level of reproductive performance is required to maximize farm profitability.

Any time a cow fails to conceive from a single service or a series of services, or if she aborts or fails to produce a live, healthy calf every 12 to 13 months, she creates a loss. Dollar losses result from less milk per day of life because more days are spent in late lactation when milk yield is low; from higher semen costs because more units of semen must be used to obtain each pregnancy; from culling of infertile cows; from lack of herd replacements because fewer calves are born; and from higher veterinary costs because examinations and treatments increase in an effort to get cows to conceive.

Production testing records from several states show that about 30 percent of our cows are culled each year. Reproductive failures are an important reason. The only more important cause is low production.

Based upon Dairy Herd Improvement (DHI) data, about 8 to 10 percent of the cattle in the nation's dairy herd of 9 million cows is culled each year because of infertility. The average difference between the salvage price of the cull cow and a good replacement is conservatively estimated as $500. This loss alone amounts to about $400 million each year.

Also, DHI records show that the average calving interval is about 13.5 months. This exceeds the recommended calving interval by 30 days and results in 130 days open for the average cow. The loss in potential income because of this excess calving interval amounts to at least $2.00 per day for each day beyond 100 days. This adds up to $60 per cow per year or an annual loss of $600 million to dairy producers. The net daily economic difference due to "reproductive cost" between a cow with a 12.5-month calving interval and a 15-month calving interval is the difference in milk yield of 50 lbs./day and 75 lbs./day.

The cumulative loss because of infertility and sterility includes both the loss due to culling and the loss due to excessively long calving intervals. Combined, these losses amount to nearly $100 per cow per year for each of the 9 million dairy cows in the United States. This loss is a conservative estimate because it does not include losses due to slowed rates of genetic progress for production traits.

Half can be saved. It amounts to nearly $50 per cow per year. Thus, the dairy producer with a 100-cow herd should be able to increase income as much as $5,000 a year by improving reproductive efficiency through careful management.

Even without creating a surplus of milk, each dairyman could capitalize on the greater part of these savings through improved efficiency; that is, higher average milk production per cow. If cow losses due to infertility could be cut, culling could then be based mainly on milk production. Thus, many high producers could stay in the herd, resulting in greater yields and possibly greater net income from fewer cows.

Progress made. During the past 50 years, tremendous progress has been made in understanding normal reproductive processes in cattle. This understanding has resulted in widespread use of artificial insemination and more recently, in development of procedures for embryo transfer and in programmed breeding through synchronization of estrus. New treatments for reproductive disorders have been discovered—many of which use naturally occurring compounds that are more desirable than some treatments used in the past.

However, automation and increased efficiency on dairy farms have resulted in larger herds with more cows in total or semiconfinement. This, along with the tremendous increase in milk production per cow, has created a situation where cows may now be more vulnerable to reproductive problems. Therefore it is essential to apply the latest information in herd management to maintain the herd's reproductive performance at the optimum. Only through careful and skillful management can the dairy producer avoid the losses due to infertility and sterility that occur in most herds.

A LIVE CALF is the goal when combating infertility. The total cost for reproductive losses exceeds $1 billion annually and amounts to about $100 per cow yearly.

Possible yearly savings by minimizing infertility

Herd size	Expected yearly loss	Possible yearly savings
50	$5,000	$2,500
70	$7,000	$3,500
100	$10,000	$5,000
200	$20,000	$10,000
500	$50,000	$25,000

Chapter 2
The bull's role

he bull's role in reproduction in a dairy herd is often overlooked because many times he has been replaced by a liquid nitrogen tank containing frozen semen. However, bulls are still used on many dairy farms and even if artificial insemination is used exclusively on a farm, the bull's role is still essential.

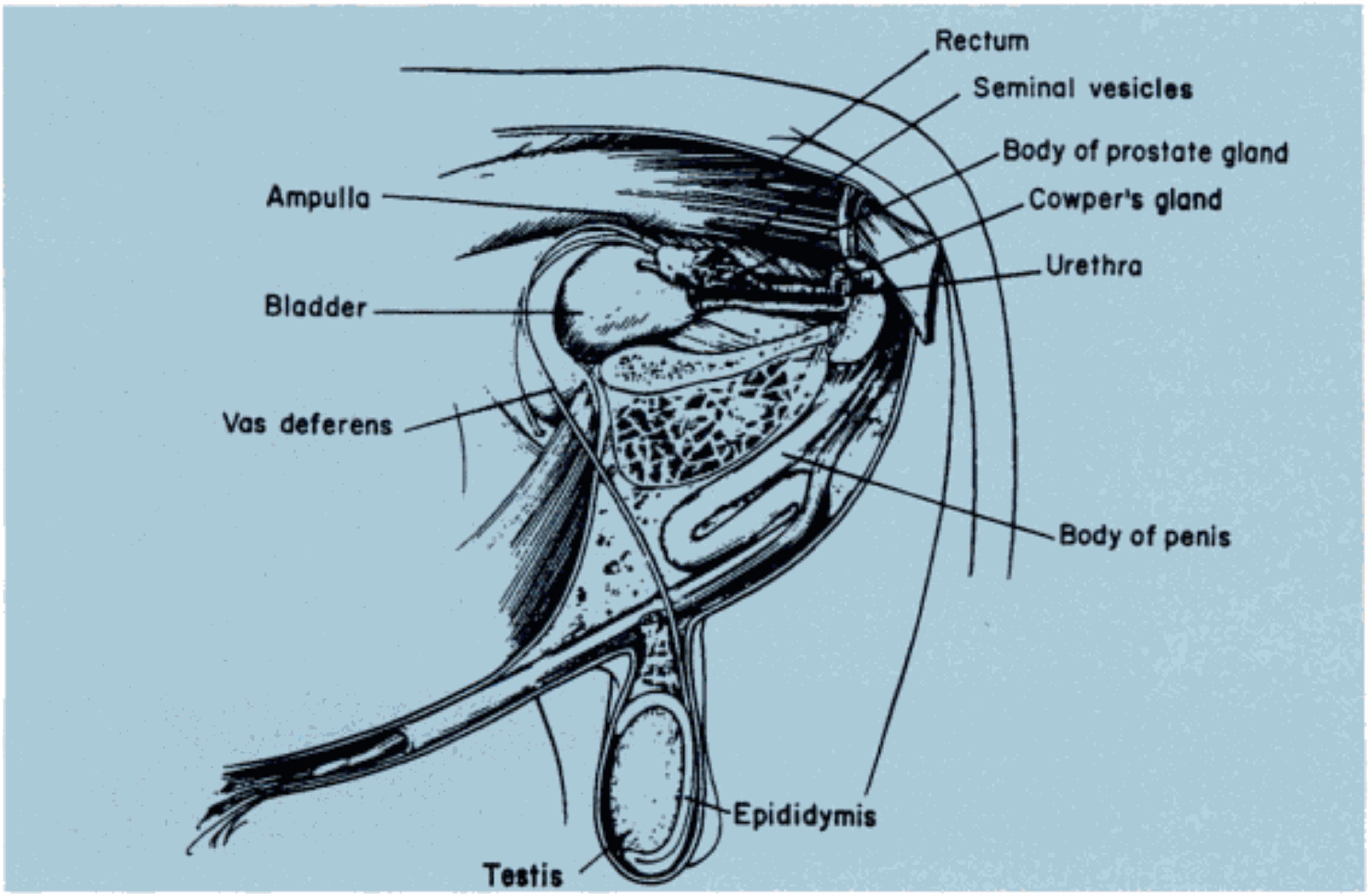
The reason we need a bull is for the sperm he produces. Sperm cells, which are necessary to fertilize the egg and produce pregnancy in the cow, are manufactured in the two testes. Each testis is a completely separate unit, and is located in its own compartment within the scrotum.

In the scrotum, the testes are somewhat cooler than body temperature. Actually, the scrotum is the "temperature regulator." By raising or lowering the testes, the scrotum provides a relatively constant lower temperature, which is essential for sperm production.

Before the bull calf is born, his testes are formed and located in the abdomen. Before birth the testes descend to their adult position in the scrotum. Occasionally, one or both of a bull's testes remain in the abdomen. A bull with this condition is known as a "cryptorchid." If both testes remain in the abdomen, the bull is totally sterile. The testes will produce no sperm because of the high body temperature. Even though he is sterile, this condition may not affect the bull's libido (sex drive).

If only one testis descends into the scrotum, it is the only one which functions and the bull will produce about half the sperm as would be expected.

Even with only one descended testis, a bull should produce sufficient sperm to provide for near normal fertility in natural mating. However, a bull with this condition should **never be used,**



ORGANS OF THE BULL. Sperm are formed in the testis and then move into the coiled epididymis surrounding the testis. When they reach the tail of the epididymis, they are ready for ejaculation. Total time from formation to ejaculation is 7 to 8 weeks. At ejaculation, sperm travel up through the vas deferens and then are mixed with fluids from seminal vesicles and prostate glands.

regardless of his genetic ability, because the condition, apparently, is inherited.

Within a testis, sperm are produced in thousands of microscopic tubules (seminiferous tubules) which join larger tubules at the core of the testis. Over a period of several days, the cells which line the small tubules divide eight times to form immature sperm cells. Fluid produced in the tubules flushes the sperm along the length of the tubule into larger rete testis at the center of the testis.

The sperm next pass into a group of approximately 15 tubules which collect the sperm as they leave the testis near its top side and enter the head of the epididymis. An epididymis is located along the side of each testis and consists of three parts that are not clearly distinguished but gradually form one highly coiled tube which is about 100 feet long. As sperm reach the epididymis, they are immotile and cannot fertilize an egg. During passage through the epididymis, which takes about 2 weeks, sperm cells change both physically and chemically, obtaining motility and fertilizing ability. Only sperm in the tail of the epididymis, which is located along the bottom of the testis, are available for ejaculation.

About 7 or 8 weeks are required from the time a sperm cell begins its formation in the testis until it is available for ejaculation in the tail of the epididymis. Consequently, if a bull is infertile today, we may have to search back one to two months to find the cause.

The photograph (lower right) illustrates the complexity of the sperm-producing machinery. This delicate mechanism is not well understood, but we know it is highly susceptible to a variety of injuries. An injury to the testis may result in the formation of an area of scar tissue which destroys many sperm-producing tubules and blocks many others.

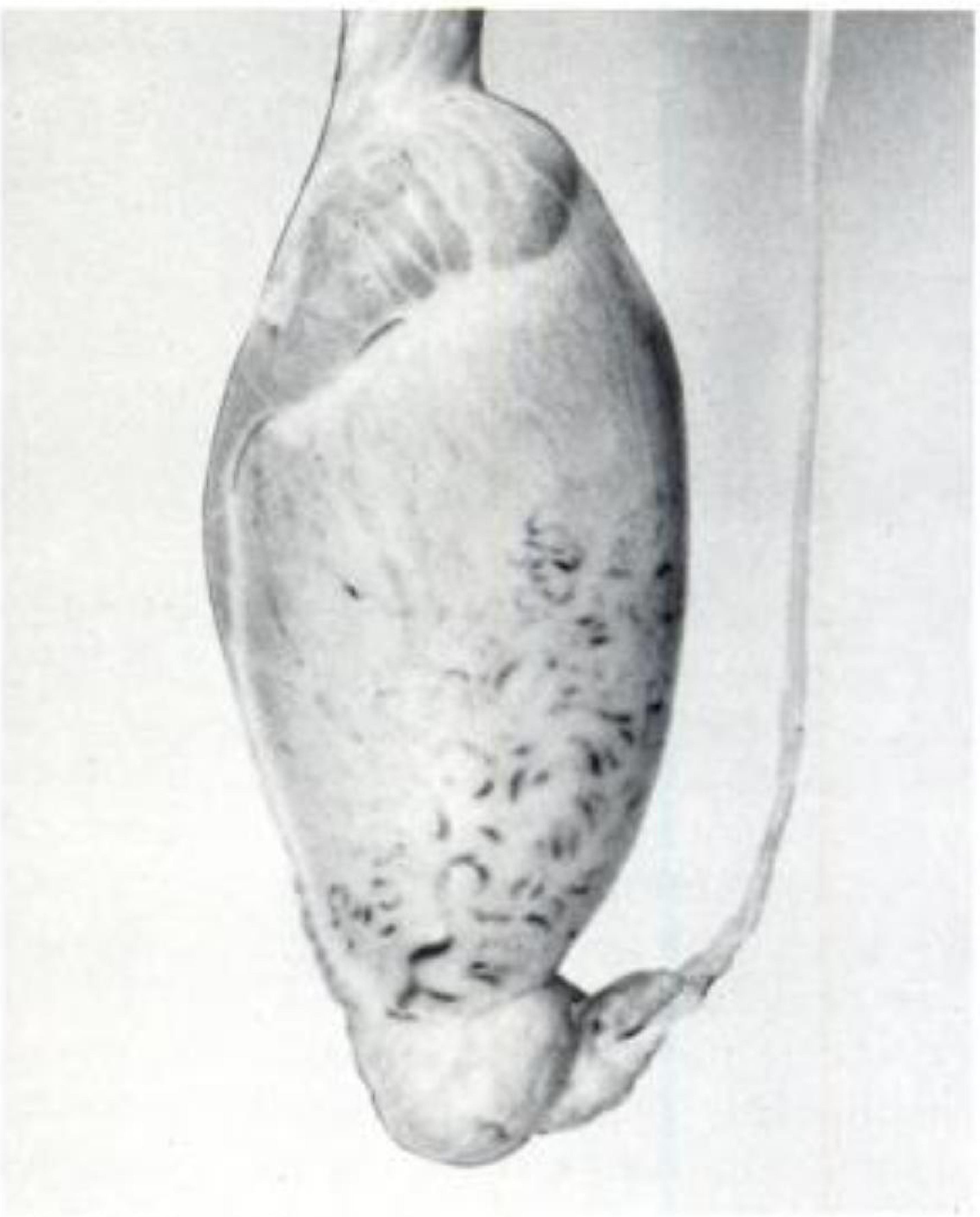
The tail of the epididymis joins the vas deferens (a 2- to 3-foot-long duct) which carries the sperm to the base of the penis near the urinary bladder. In the testis, epididymis, and vas deferens, sperm are not motile. Presumably, immobility conserves their energy until ejaculation when they begin swimming vigorously.

In most bulls, sperm production goes on continuously from puberty until death. However, older bulls produce fewer sperm because of damage and degeneration of some spermatogenic tissue.

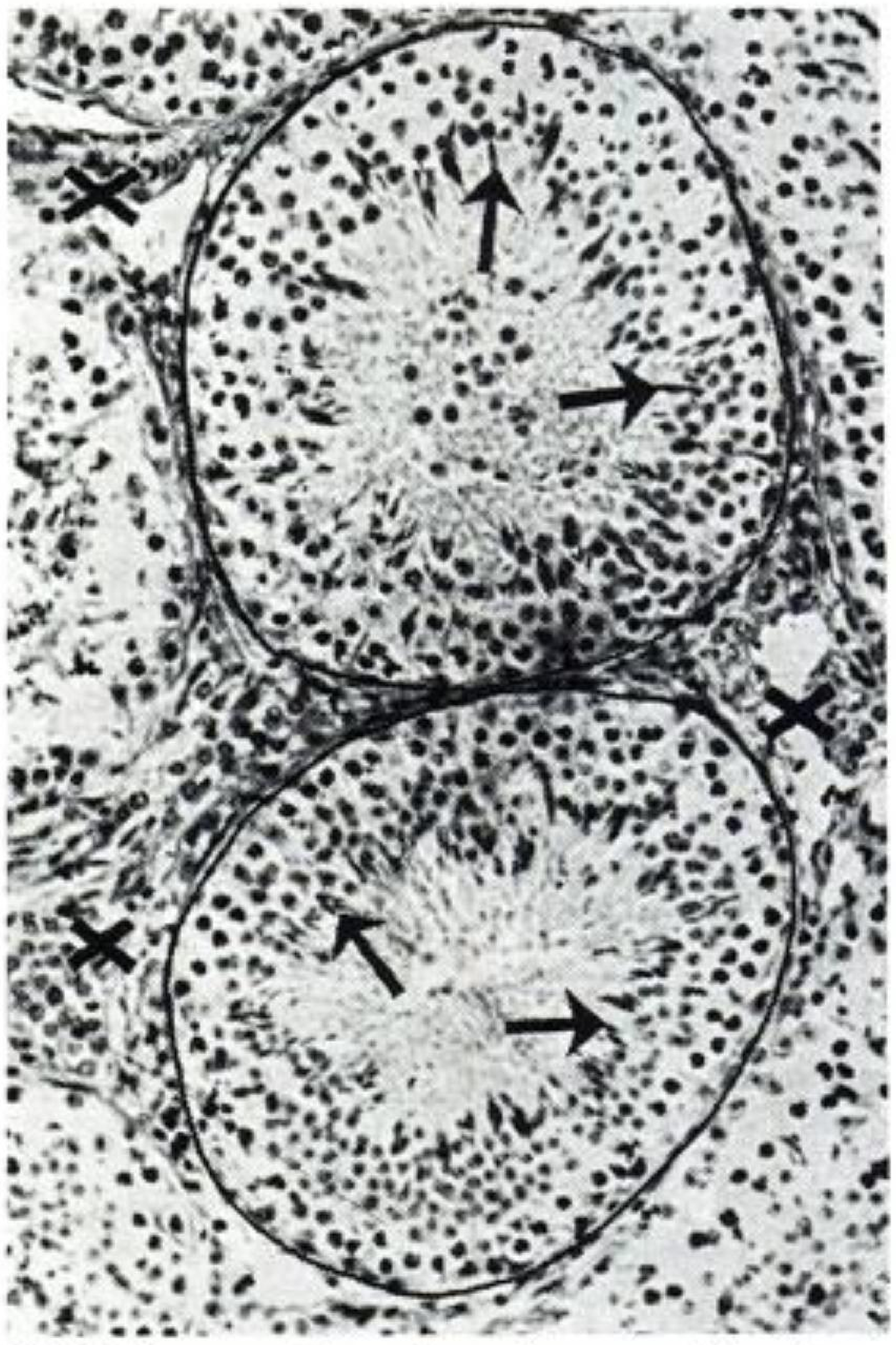
Ejaculation forms semen. At the moment of ejaculation, split-second muscular contractions of the vas deferens and epididymis propel sperm into the penis. At the same instant, contractions of the accessory glands force their fluid contents into the penis. The resulting mixture of sperm with fluid (semen) is instantly propelled through the penis to the outside.

Sperm make up only about 20 percent of the total volume of semen. The rest of the ejaculate comes from the accessory sex glands located along the bull's reproductive tract.

The main accessory glands are the seminal vesicles, located at the



BULL TESTIS has been dissected out of scrotum. The epididymis is on the top and left side of the testis. Vas deferens exits from the bottom at right.



TESTIS as seen through a microscope. Two tubules, within which sperm are produced, are outlined. Elongated dark spots (arrows) are newly formed sperm heads. Male sex drive hormone is produced by the cells (x) between tubules.

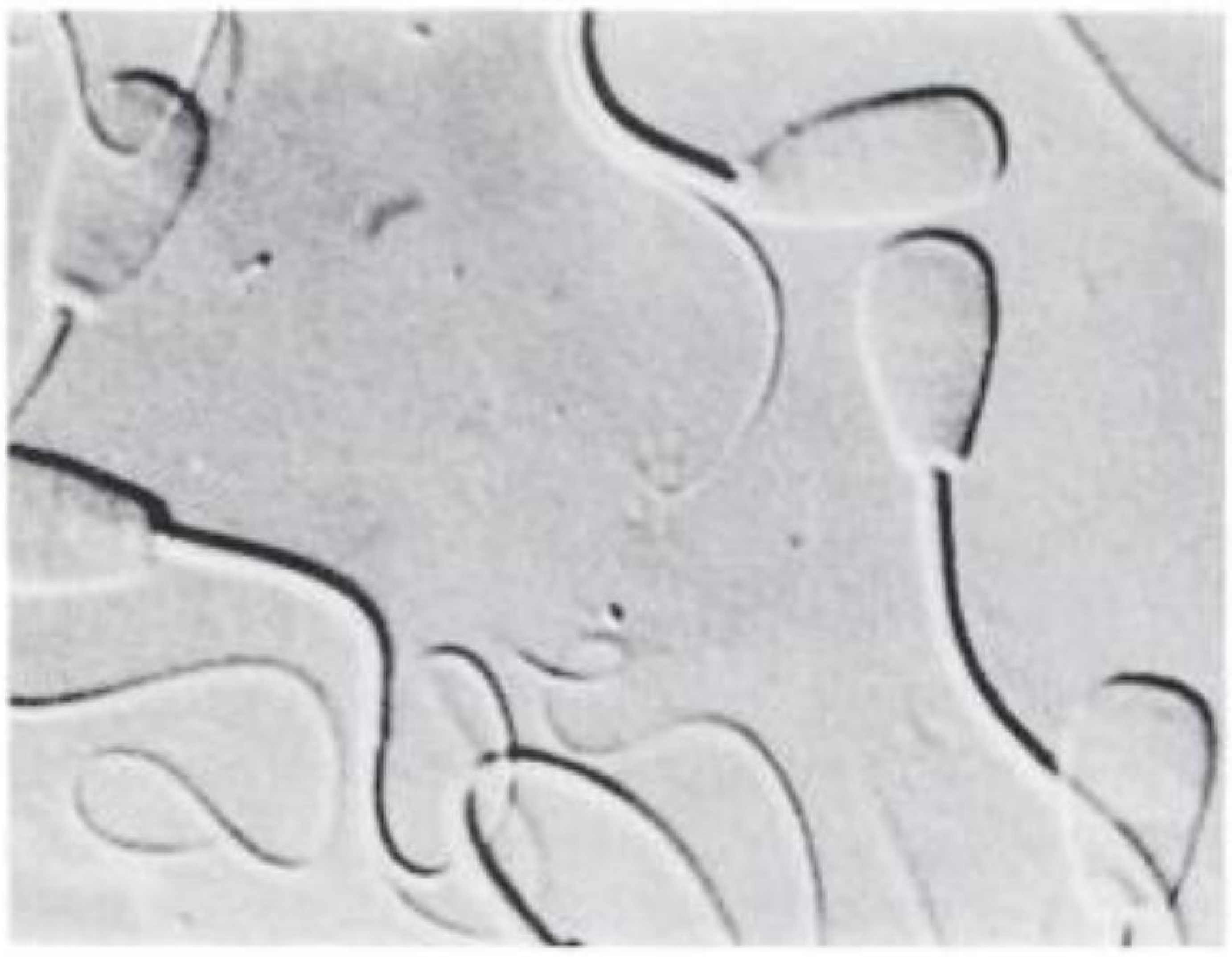
base of the penis near the urinary bladder, as shown in the diagram (see diagram, page 7). Fluid from the seminal vesicles is rich in fructose, a sugar which may serve as an important nutrient for sperm.

The volume of fluid contributed by the prostate and Cowper's glands is small compared to that of the seminal vesicles. Fluids from the prostate and Cowper's glands serve to flush out the penis, cleansing and lubricating the urethra and adding only a small volume to the semen. Fluid from the accessory sex glands functions as a media or carrier of sperm, providing energy for metabolism and proper pH and salt balance. However, these fluids do not maintain sperm survival for but a short period of time. Either the cow's fluid or chemically defined extenders are needed to prolong the life of sperm.

The testes are regulated by hormones from the pituitary gland. In turn, the testes produce the male sex hormone, testosterone, which controls the development and secretion of the secondary glands. Thus, the testes have a dual function: producing sperm, and producing the male sex hormones.

Testosterone is manufactured by the cells that separate the small sperm-producing tubules in the testes. This hormone is responsible for the male **sex drive (libido).** Malfunction of the testosterone-producing cells of the testes also can cause infertility, usually because of a lack of libido.

At about 6 to 9 months of age, bulls reach puberty and start producing sperm cells. The onset of sperm production (spermatogenesis) is controlled by hormones produced by the anterior pituitary gland. The primary hormones from the pituitary that stimulate sperm production are luteinizing hormone (LH) and follicle stimulating hormone (FSH). However, other pituitary hormones such as prolactin may also be involved.


Normal sperm cells magnified about 2000x.

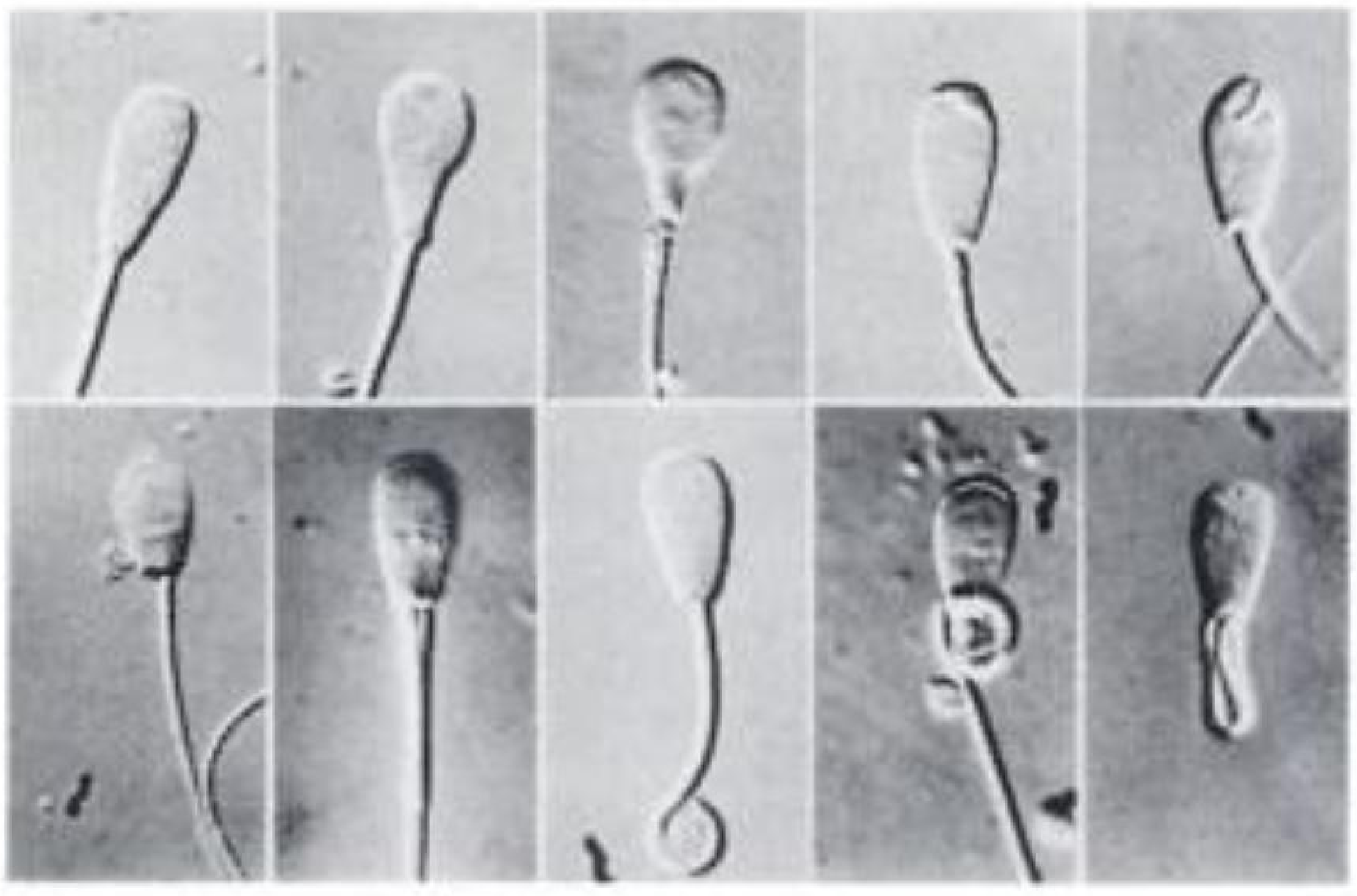
Bulls reach the adult rate of sperm production by about 12 to 18 months of age. But they produce only half as many sperm as a mature bull because their testes are only half as large. The amount of sperm produced is directly related to the size of the testes.

Research from Pennsylvania State University has revealed that mature bulls produce about 70 billion sperm cells each week. Nature has provided a great excess of sperm so there is a good chance that at least one will find its way to the egg for fertilization. A successful mating results in the union of one sperm and egg. This is one of the fundamental principles underlying artificial insemination. The excess sperm from any one ejaculation can be "harvested" and used to breed many more cows than would be possible with natural mating.

A bull in natural service might ejaculate from 7 to 10 billion sperm cells just to breed one cow. Most of these sperm are wasted. If this ejaculate with the same number of sperm were used in artificial insemination, this ejaculate could inseminate about 300 cows. In fact, a single bull has been known to produce enough semen to breed more than 100,000 cows a year. Today, semen can be frozen and stored indefinitely in liquid nitrogen (at -320 °F), providing a means for a bull to be used to breed cows long after he is dead.

Even in an artificial insemination stud, one would rarely expect to obtain as many as 70 billion sperm a week from a bull. The actual number of sperm obtained depends upon how the bull is prepared for ejaculation and how frequently he is ejaculated. When semen is collected twice a week with good preparation (sexual stimulation) of the bull, between 20 and 40 billion sperm usually are obtained each week.

Sperm head carries "payload". The head of the sperm is the "payload." Within the nucleus are the chromosomes, the genetic material that transfers


ABNORMAL SPERM (magnified about 1500x). Head abnormalities appear on upper row. Tail abnormalities appear on lower row.

hereditary information from the bull to the resulting calf. The tail of the sperm simply serves as a means to propel the sperm in its search for the egg.

A sperm cell is extremely complex. It is as intricate as an electronic computer. All of its parts have to work properly to insure normal fertility. Many sperm abnormalities which can result in infertility may be detected with a microscope. Some of these abnormalities are illustrated in the photograph (lower right, previous page.)

Contrary to the general opinion that overuse may harm a bull's fertility, experiments indicate that frequent ejaculation does not harm fertility. In fact, a study in New York showed that mature dairy bulls (10 years old) can be ejaculated daily for as long as eight months without measurable detrimental effects on the fertility of the semen produced.

The number of cows that a bull can serve in a given period of time varies considerably among bulls. Studies with beef bulls indicate that a bull can serve up to 40 or more cows within a 3-day period. However, it is **not a good practice to run a bull with the herd** because disease can be spread, risk of injury is increased, and most importantly the loss of genetic advancement occurs by using bulls of usually unknown or inferior genetic merit.

Young bulls which have been fed adequately and have grown properly should produce fertile ejaculates by 6 to 9 months of age. However, fertility is lower in young bulls, and the serving capacity of young bulls is lower than that for more mature individuals. Therefore young bulls in natural service should be used carefully to avoid overwork.

Actually, there may also be some danger of infertility in underuse of bulls. It is common to find more dead sperm in ejaculates taken from bulls after several weeks of sexual rest than in ejaculates from bulls used more frequently. Sexual rest beyond three to four days does not increase the number of sperm harvested.

It is recommended that a bull pass a breeding soundness evaluation prior to service, and this is especially important when the bull may be involved in an infertility situation. The breeding soundness examination should include a semen evaluation in addition to an internal and external examination.

The average volume of ejaculated semen collected with an artificial vagina is 5 to 15 ml. Color of the semen should be milky to creamy white. Occasionally, a yellow semen sample is obtained which is high in betacarotene and is considered normal. When fresh semen is examined microscopically, at least 60 percent of the sperm should be swimming vigorously.

The average semen sample of a mature bull contains 800- to 1,200-million sperm per milliliter. The number of abnormal sperm in the semen sample should not exceed 20 percent. Abnormalities of the **head** of the sperm involve the DNA and are referred to as **primary** abnormalities. Abnormalities of the tail involve motility of the cell. Both of these abnormalities reflect malfunction of the testes. Droplets found on the sperm tail indicate immature sperm and reflect malfunction of the epididymis. Overuse of the bull **cannot** cause the release of immature sperm.

Whether a you keep a bull or use artificial insemination, let's not forget that the bull is half of the breeding herd. This is as true for fertility as it is for milk production. In fact, use of a low fertility bull is an easy way to reduce reproductive efficiency in the herd.

Bulls must be fertile. There is no evidence that a bull's fertility is affected by his Predicted Transmitting Abilities (PTAs) for Milk, Fat, Protein and Type. Thus, in selecting bulls to use, it is best to choose those that have high PTA MF$ or PTA CY$ (Cheese Yield Dollars). Today there are enough genetically superior bulls in most bull studs so that bulls with low fertility should be culled.

Chapter 3

The cow's reproductive tract

ALL LOWER FORMS of animals, such as fish and reptiles, place their young mostly at the mercy of their environment. In contrast, mammals (animals that nurse their young) provide a sheltered environment for fertilization and for the developing young, at least until birth. This "shelter" in the female reproductive tract allows most offspring to survive the early stages of growth.

Nevertheless, we frequently find abnormalities in the reproductive tract of the cow that cause pregnancy failures. Some of these defects originate with the cow herself and some are caused by people — their poor management. Among these are unskilled artificial insemination or veterinary practices that damage the fragile parts of the reproductive tract. Sound dairy herd management will minimize most of these pregnancy losses and eliminate others.

Well protected. The reproductive tract of the cow is located just under the rectum, largely within the pelvic girdle. This bony cavity protects the tract, at least until the middle of pregnancy. Actually, the uterus and ovaries are located ahead of the pelvic girdle, within the abdominal cavity just above and behind the rumen and intestines. They are held in that position by a tough sheetlike ligament (broad ligament) that carries the weight of not only the reproductive tract but also of the calf within it. The tract is richly supplied with blood vessels and nerve fibers.

Unfortunately, many of the vital organs of the reproductive tract are located so they cannot be seen. However, they are close enough to the rectum that they can be felt (palpated) through the rectal wall. It is fortunate because skilled veterinarians, by rectal palpation, can make many diagnoses that otherwise would not be possible. In addition, convenient access to the cow's reproductive organs also provides an opportunity for an unskilled person to cause considerable damage or even sterility.

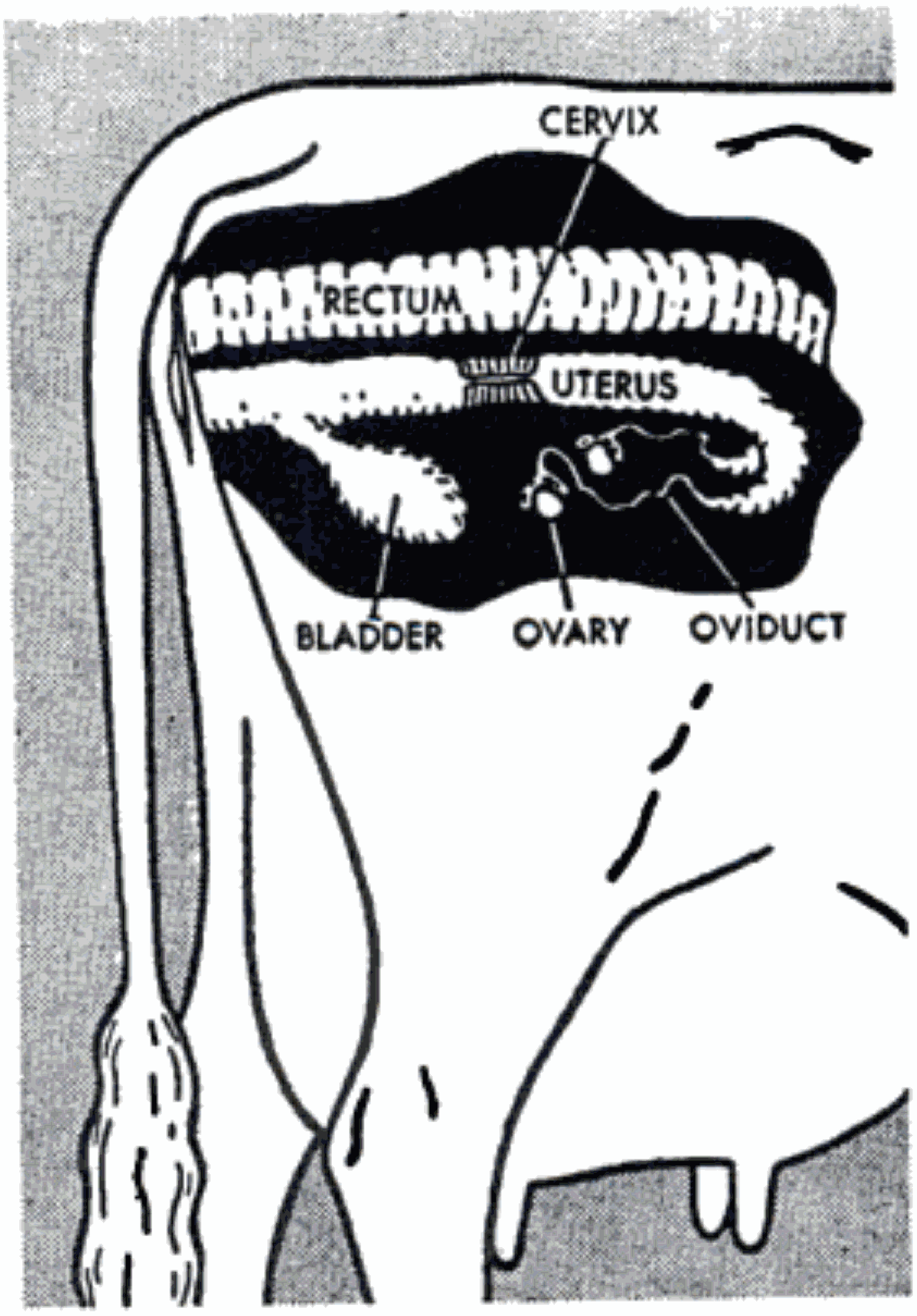
Some of the reproductive organs of the cow are very delicate. They must be handled only by a person who is aware of the danger of permanent damage.

The vulva is the external genitalia and entrance to the vagina. The vulva and vagina are the only parts of the reproductive tract normally visible without surgery. The vagina serves not only as the birth canal but as a passageway for semen and the exit for urine.

In the cow, the vagina is a collapsed tube, normally about 12 inches long. The walls of the vagina are thin and elastic. Expansion is limited only by the walls of the pelvic girdle.

The vagina is lined by a membrane containing thousands of mucus-producing glands. These glands continually secrete a watery, clear mucus which bathes the vagina and flushes out foreign material that may have gained entrance, especially during the heat period. Even with this defense mechanism, the vagina frequently is invaded by organisms, causing low-grade infections.

Cervix is tough. The inside end of the vagina joins the cervix, an extremely tough and fibrous organ. The cervix, 4 to 5 inches long, has a narrow opening throughout its length. This opening or cervical canal is sur-



COW'S REPRODUCTIVE TRACT. Note how close organs are to the rectum, making possible a veterinarian's examination by palpation (touch).

rounded by heavy folds of tissue. These folds form 3 or 4 prominent ridges that encircle the interior. These are commonly spoken of as the annular rings and act to prevent entrance of any foreign material. Consequently, **the cervix serves as a very effective door between the vagina and the uterus.** The cervix normally dilates (opens) only during the heat period and at the time of calving.

The cervix also is lined with mucous glands that add their secretions to those of the vagina. The mucous glands of the cervix are most active during the heat period. During pregnancy, the cervical mucus hardens and seals off the cervix by forming the cervical plug that dissolves before calving. At calving, the cervix dilates and allows the fetus and surrounding membranes to be expelled from the uterus.

The cervix is continuous with the body of the uterus, which is about 5/8 to 1 inch long. As the uterus proceeds forward, it is divided into two horns, each about 12 to 16 inches long, which are shaped similarly to the horns of a ram. As with a ram's horns, the uterine horns are larger at the body of the uterus and become smaller towards the uterotubal junction.

The wall of the uterus is made up of two layers of smooth muscle plus an inside lining, called the uterine endometrium. Contraction of the smooth muscles causes the expulsion of the fetus at the time of calving.

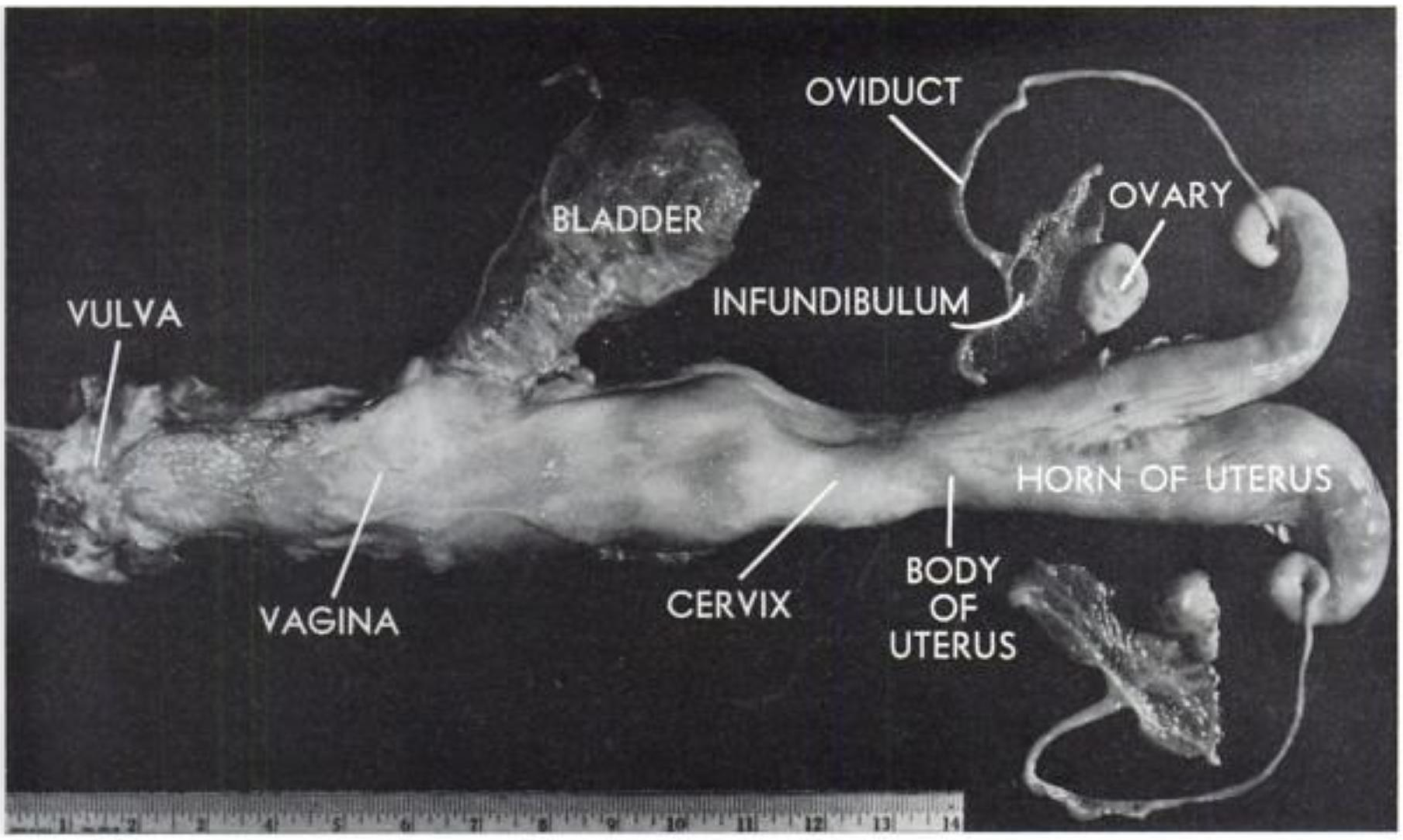
Similar contractions during and after estrus assist in transporting inseminated sperm to the site of fertilization. The uterus is capable of undergoing great changes in size and position in order to accommodate the developing calf. Following calving, the uterus gradually regains its normal shape and size. This process is called involution. Rebreeding should be delayed at least 40 days until the reproductive tract has recovered from the previous pregnancy.

Uterine lining very fragile. Superficially, the uterus appears quite tough. However, microscopic examination shows the inside lining (endometrium) is fragile and easily damaged.

Arranged in rows along the inside of the uterine horns are 80 to 120 "bumps" (caruncles) which range up to 1/2 inch in diameter. These caruncles are sites to which the placenta surrounding the calf attach via placental cotyledons.

In the pregnant cow, the caruncles increase in size about 10 times. Nutrients and oxygen from the cow's blood diffuse through the cell layers in the uterine caruncles to the cotyledons of the placenta and eventually to the calf.

Waste products from the calf's blood diffuse back into the cow's blood where they are eliminated.



REPRODUCTIVE TRACT dissected from a cow. Notice blister-like follicle on ovary at top right. In the cow, of course, the bladder is located below the vagina. Oviducts are more coiled than shown here, and funnel-shaped infundibulum would partially surround the ovary.

There is no mixing of the blood supply between cow and calf.

The area between the caruncles is lined with microscopic-sized uterine glands that secrete substances (uterine milk) into the uterine lumen (center cavity). The secretions contain nutrients and hormones that play important roles in the development of the embryo. The amount secreted is controlled by ovarian hormones carried in the cow's blood and by hormones produced by the developing embryo.

Phagocytes combat bacteria. During estrus, there are phagocytes (white blood cells) in the uterus that rapidly engulf and destroy foreign organisms. However, phagocytes are not prevalent during the intervals between heat periods. As a result, if any infectious organisms survive the heat period, they easily may infect and inflame the uterus once the heat period is over.

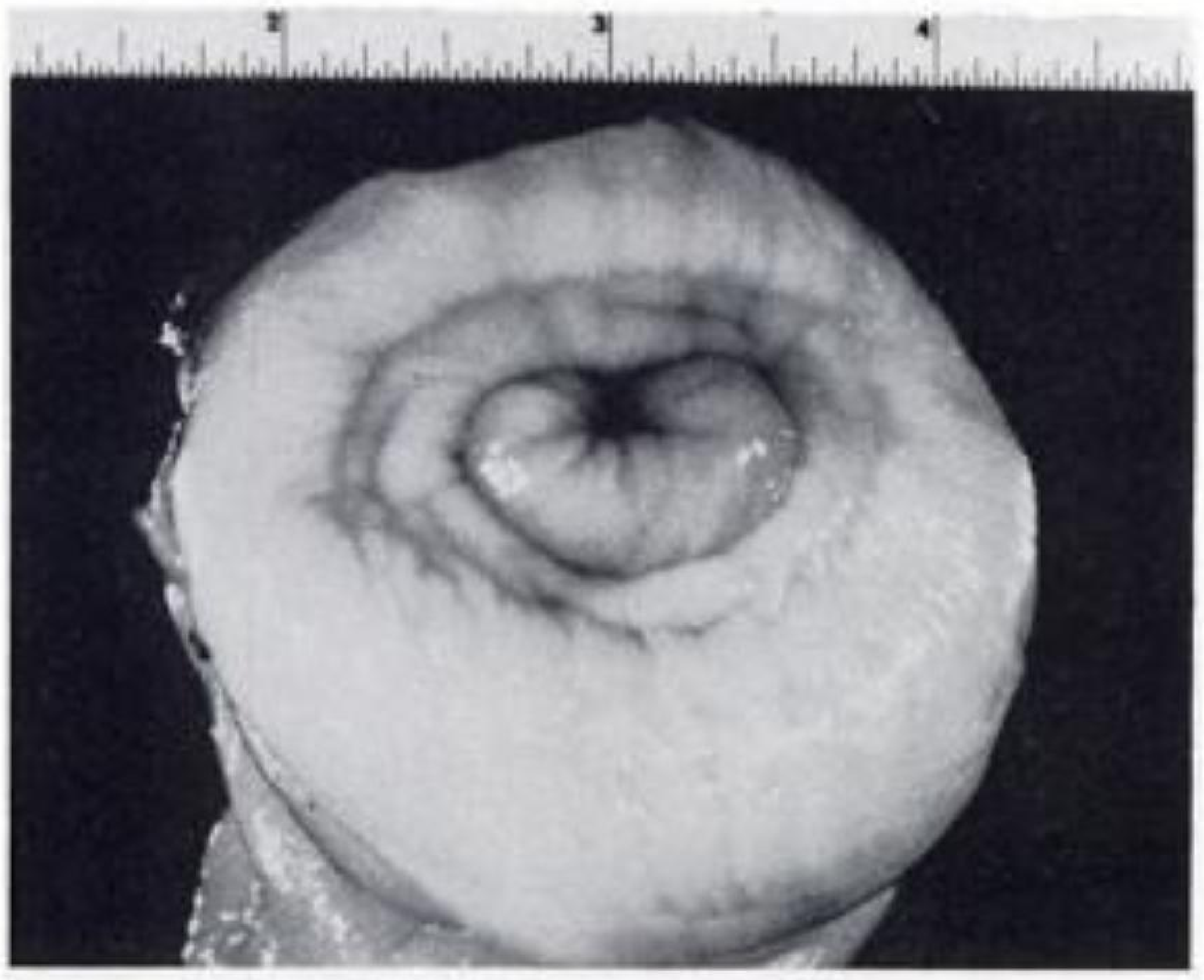
The uterus, of course, is the place where the calf develops, which gives evidence that a perfect environment exists within the uterus for growing organisms. With this fact in mind, perhaps it is reasonable to expect that bacteria might find the uterus to their liking, at least during the time between heat periods.

At the front end, each uterine horn narrows to a small opening and joins an oviduct at the uterotubal junction. The two oviducts are fragile, highly coiled tubes. Each is 6 to 8 inches long and about 1/8 inch in diameter. The lining of the oviduct is very specialized and delicate. It also contains glands, but their secretions are watery. We believe this secretion usually flows away from the uterus toward the ovary.

The uterotubal junction between the uterus and the oviduct serves as a valve. It is tightly closed except for short times when it allows sperm and eggs through. At all other times, you hardly can force liquid through from the uterus into the oviduct or from the oviduct into the uterus. The opening and closing of this uterotubal junction is controlled by hormones produced by the ovary.

The rate of movement of the fertilized egg through the oviduct into the uterus is controlled by the action of ovarian hormones (estrogen and progesterone).

Funnel for the egg. The other end of the oviduct, adjacent to the ovary, is shaped like a funnel and is known as the infundibulum. The large photograph on the bottom of page 12 illustrates how delicate the infundibulum is. It partially surrounds the ovary. The infundibulum is lined with tiny hair-like projections called cilia. These cilia beat in a regular rhythm to carry the egg toward the ostium, the opening into the oviduct (tubal portion). The two ovaries are oval-shaped, usually 1 to 2 inches long. They have two functions: producing ova (eggs) and hormones.



OPENING OF CERVIX protrudes into vagina. Vagina has been dissected off to show this view. Mucus from cervix glistens around the opening.

If we examine an ovary microscopically, we find hundreds of eggs, each egg at the center of a group of cells. The egg with its surrounding cells is known as a follicle. If we could watch a particular follicle, we would see the cells around the egg multiply. As a result, the follicle becomes large enough to be just visible to the naked eye.

Next, a fluid-filled cavity appears within the group of cells near the egg. This fluid-filled cavity enlarges, slowly at first, but very rapidly just before the heat period.

The cells that surround the ovum (egg) and line the fluid-filled cavity of the follicle produce the female sex hormone, **estrogen**. As the follicle becomes larger and larger, it secretes more and more estrogen into the bloodstream of the cow. **The high levels of estrogen initiate the heat period and sexual behavior** (standing and mounting).

At this time, the follicle on the ovary may be half as large as the ovary itself and may be palpated through the rectal wall. It appears to be a very turgid blister. Then it bursts, releasing the fluid within it along with the ovum. The release of the egg and fluid is known as ovulation, and occurs about 24 to 32 hours after the onset of heat.

About the time of ovulation, the infundibulum (funnel) of the oviduct becomes quite active. It "grasps" the ovary as if it were searching for the ovum. If all goes well, the ovum is directed into the oviduct. Occasionally, the egg is not picked up by the infundibulum. As a result, it is lost in the body cavity.

Hopefully, the ovum will be fertilized by a sperm cell waiting in or passing through the oviduct. The fertilized egg then further develops and enters the uterus where it may develop into a calf.

After ovulation, when the follicle burst open, it begins its "second life." Some of the cells that lined the cavity of the follicle wall begin to multiply. These cells secrete the hormone of pregnancy, **progesterone**. Within one day, these cells will grow to the point that they form a spherical mass as much as 1/2-inch in diameter.

This new structure, which is yellow to red in color, is the **corpus luteum**, sometimes called "yellow body." It continues to grow for 10 or 12 days, all the time secreting more and more progesterone into the bloodstream of the cow. At this point, the corpus luteum may be nearly as large as the ovary itself.

If the ovum is fertilized and the cow becomes pregnant, the corpus luteum continues to secrete progesterone throughout pregnancy. If the ovum is not fertilized, the corpus luteum will degenerate 16 to 18 days later, while at the same time, another follicle begins to enlarge rapidly. (But this is a story for the next chapter where we will describe the controls that direct the formation of the follicle and the corpus luteum.)

Frequent defects. It is not at all unusual to find heifers with abnormalities of the reproductive tract. One of the most frequent abnormalities is a blind (dead end) cervix. Such a heifer is totally sterile.

Other times we may find a cervix with two channels into the uterus, or perhaps one open channel and one blind channel. If one pathway is blind, the heifer is still usually fertile; the inseminator may have trouble finding the open channel.

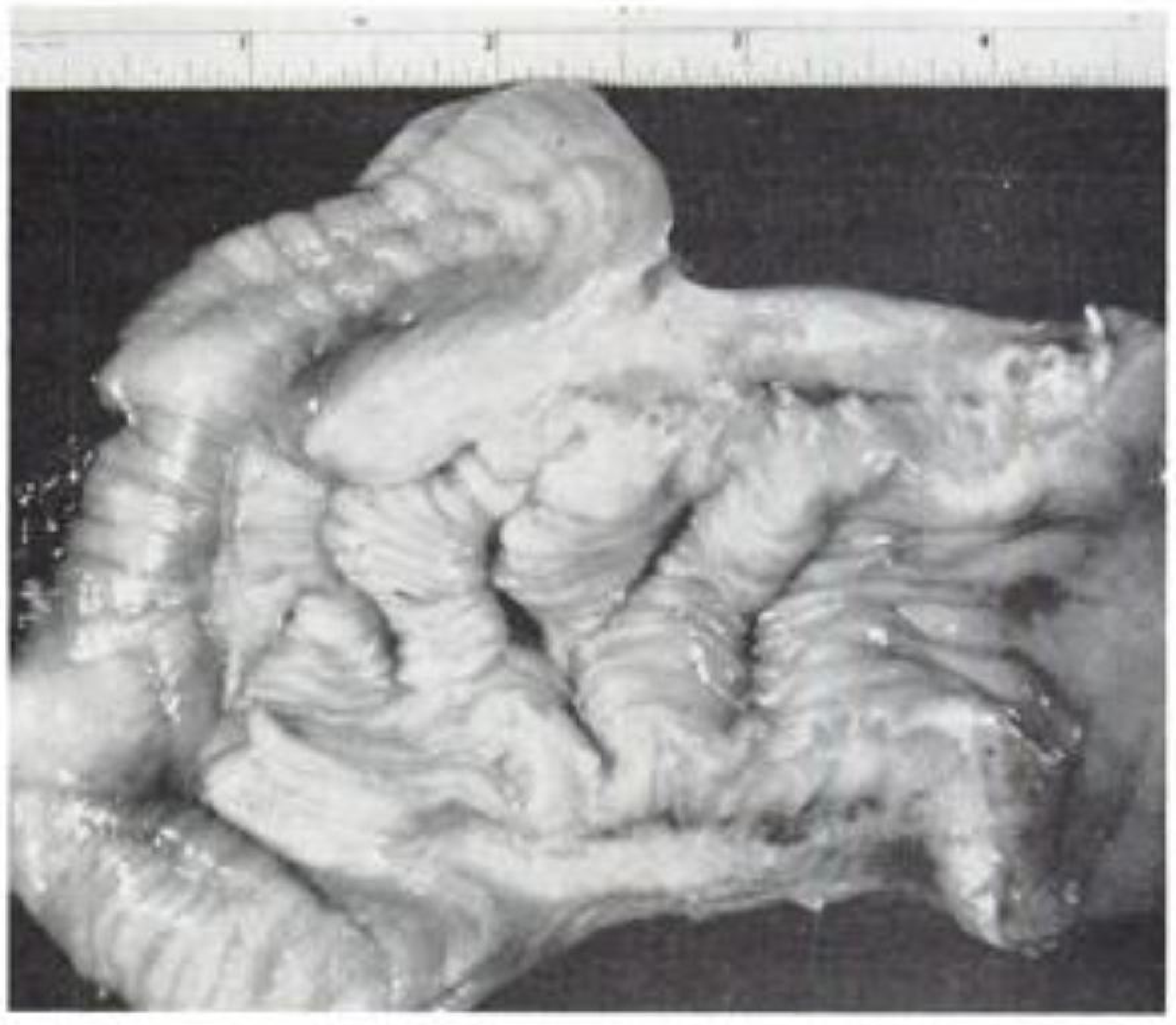
Other parts of the reproductive tract also may be missing. Sometimes heifers have only one uterine horn or only one functional ovary capable of producing hormones and eggs.

The **freemartin** condition is probably the most frequent abnormality involving the underdevelopement of the female reproductive tract. **It occurs in over 90 percent of heifers born twin to a bull.**

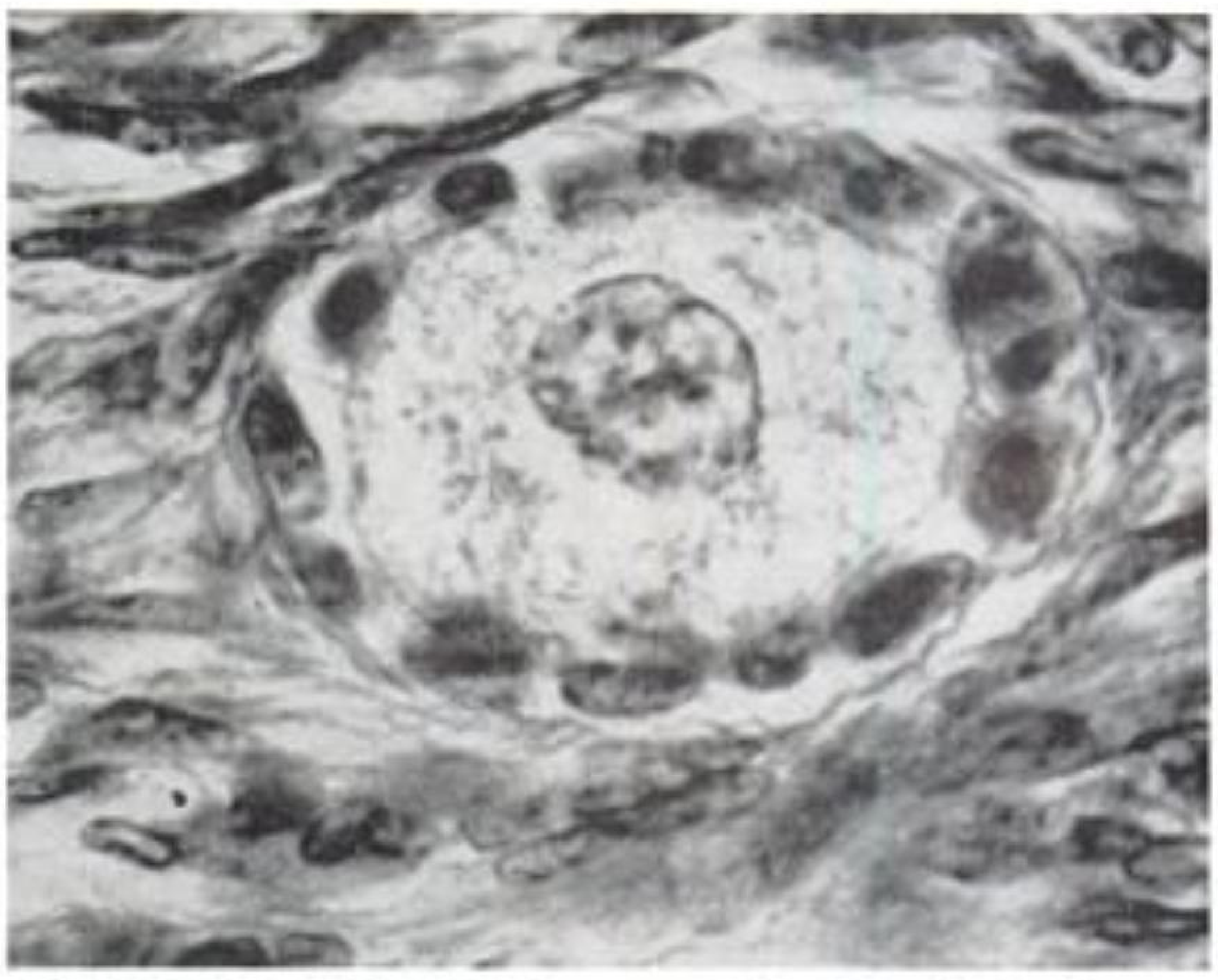
Usually the tract of a freemartin is closed at the opening of the vagina, just in front of the opening of the bladder. Therefore, an ordinary test tube (6 inches long) can be inserted only 2 to 3 inches into the vagina. In the normal heifer the test tube can be inserted to its full length into the vagina.

In some freemartins the tract is complete up to the cervix. In these cases, the freemartin condition can be detected by examining the chromosome makeup of a sample of white blood cells collected from the animal. In freemartins, some white blood cells contain the chromosome makeup of females (heifers), whereas other cells from the same sample contain the chromosome pattern of males (bulls).

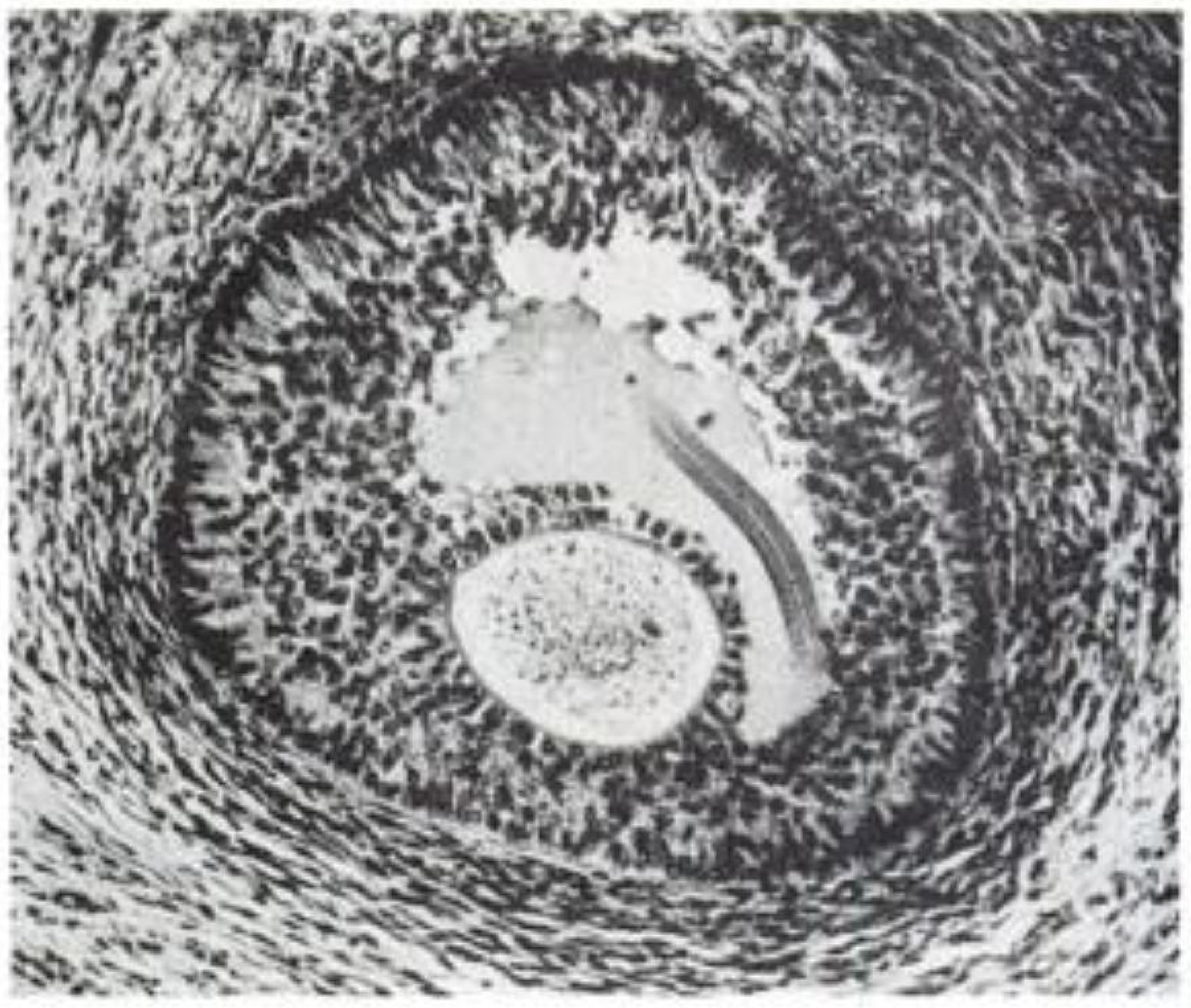
Because the odds of a freemartin heifer being fertile are less than 10 percent, it is recommended to feed her out for beef or sell her for the same purpose.



INSIDE OF CERVIX cut open. Notice the heavy folds of tissue. In the cow, the vagina would be at the left and uterus at the right of this cervix.



COW EGG IN OVARY (magnified 400x). Nucleus is in center, surrounded by cytoplasm, and one layer of cells producing female sex hormone.



FOLLICLE IN COW'S OVARY (magnified 200 x). Egg is below fluid-filled cavity, which is, in turn, lined with cells that produce estrogen.

Chapter 4

Reproduction

Full-time job for the dairy cow

THE FIRST THING WE demand of the dairy cow is that she produce 8 to 12 tons of milk a year. But let's not forget that, before we can get this milk, the cow must have a calf about once a year.

Ideally, we would like every dairy cow pregnant or recovering from pregnancy at all times. This is truly working her full time. It goes on continually. At least, it goes on until some part of the complicated process breaks down.

Among the causes of infertility, the body parts that control the functions of the reproductive tract are notorious. Many of these controlling centers are located far away from the reproductive tract. In recent years we have come to understand how some of these glands affect reproduction and how aberrations of their functioning can cause infertility.

Chemical messengers. The most important controls of reproduction are the hormones that regulate the estrous (heat) cycle, pregnancy, birth and even the secretion of milk.

Hormones are "chemical messengers." They are secreted by an endocrine gland at one location and move into the bloodstream. The blood carries the hormone to an organ at another location where it delivers its message by affecting the target organ in some way. The hormones only act on or stimulate target glands or organs that contain specific receptor sites to which the hormone binds.

In a sense, hormones act like nerves. Nerves also deliver messages, but their messages do not go through the bloodstream. The messenger for nerves is thought to be similar to an electrical impulse. Certainly, the nerves have profound effects upon reproduction. In fact, specialized nerves located in a neuroendocrine center of the brain, called the hypothalamus, actually control reproduction and milk secretion by secreting hormones that control the pituitary gland.

Of all the endocrine glands, the pituitary gland occupies a position of primary importance. It secretes several hormones, many of which control the function of other endocrine glands. Because of its tremendous influence on other body glands, the pituitary is known as the master gland of the body. But we now know that the pituitary is controlled by the hypothalamus. And the hypothalamus in turn is controlled by higher brain centers in the central nervous system.

The pituitary is located at the base of the brain, close to the hypothalamus. In the cow, it is only about 3/4 of an inch in diameter. Its location near the brain is essential to some of its functions since the hypothalamus gives directions to the pituitary, telling it what to do and when to do it.

The hypothalamus controls the secretion of pituitary hormones by secreting other hormones into a specialized portal system that supplies blood to the pituitary. Recently some of these hypothalamic hormones have been synthesized, a major breakthrough. The chemical structure of hypothalamic hormones is much simpler than that of pituitary hormones. Therefore they are less expensive to synthesize than the more complex protein hormones of the pituitary. Hypothalamic hormones are already being used to treat such abnormal conditions as cystic ovaries, and their use in controlling reproduction, growth and milk production will increase in the future.

Among the hormones secreted by the pituitary gland are those that specifically control reproduction. These are known as gonadotropins because they control the gonads (the ovaries of the cow and the testes of the bull). The gonadotropins all have long descriptive names. However, we will use the abbreviations commonly used by veterinarians.

Let's take a look at the body chemistry of the cow during the estrous cycle. The pituitary secretes the hormone known as "follicle stimulating hormone" (FSH), and the blood carries FSH to the ovaries where, as its name implies, it stimulates the growth of follicles.

A group of follicles begin to

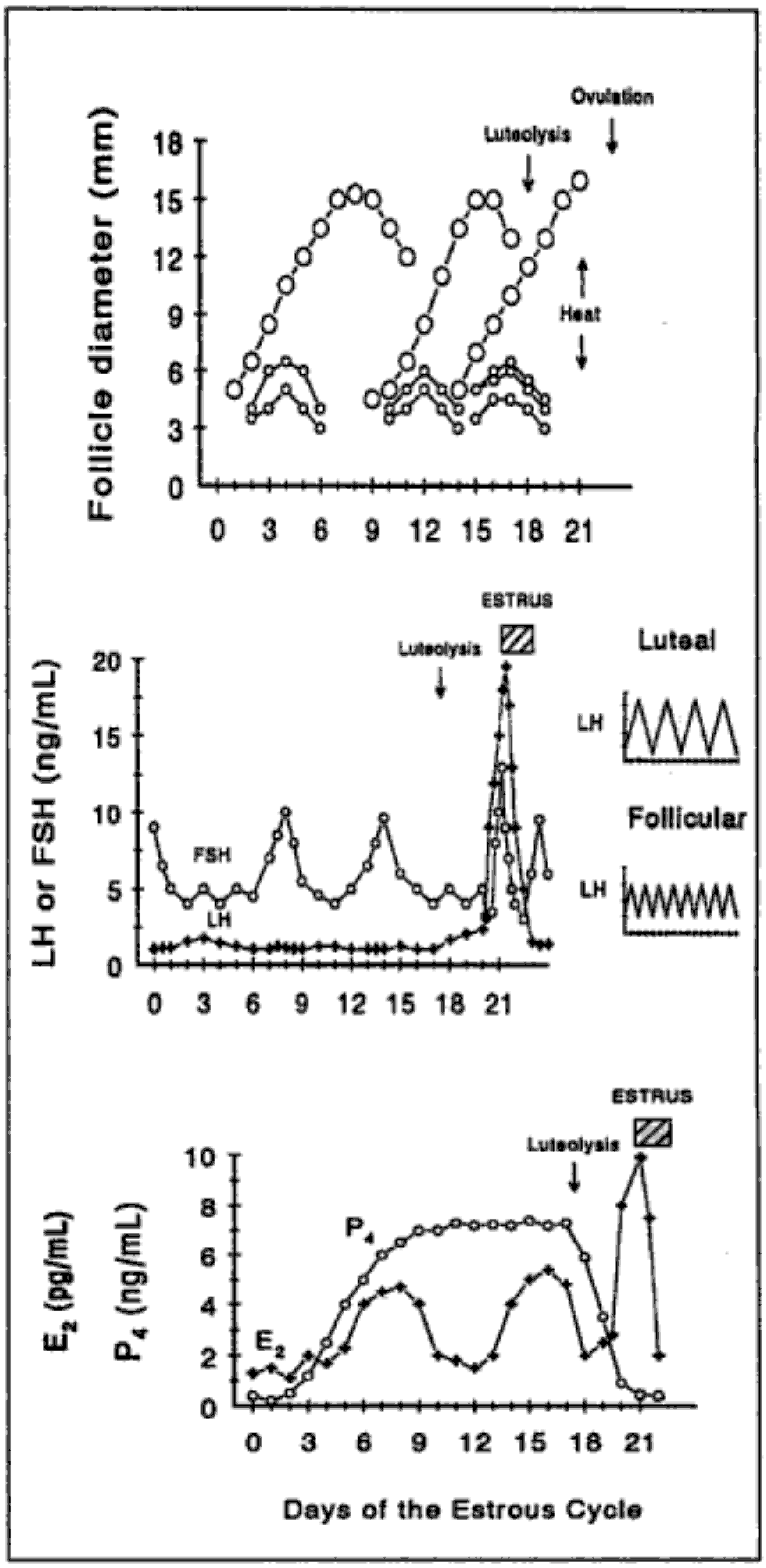
grow in response to a transient increase in blood concentrations of FSH. This increase in FSH is observed one or two days before the appearance of several new follicles in both ovaries. Shown in the figure (top right) is the diameter of several follicles during the estrous cycle of a cow. This cow has three groups or "waves" of follicles that develop during the cycle. On days 1 and 2, three follicles were visualized, but only one grew (dominant) from this group (cohort) and "dominated" the other smaller (subordinate) follicles. The subordinate follicles undergo atresia (death) and are no longer useful as potential follicles.

The first dominant follicle undergoes a growth phase (days 1 to 6), a static phase (days 7 to 9), and a regressing phase (days 11 to 12 or longer). The second wave of follicles visualized appeared around day 9 or 10, one of which dominates the other follicles and becomes the second dominant follicle, which happened to regress before luteolysis (death of the corpus luteum). Therefore, a third wave of follicles, which began to grow about day 14 or 15, appeared with another dominant follicle emerging and eventually ovulating.

Although any number of follicles (beginning diameter of 0.1 inch) can make up a wave of follicles, usually only one to six develop per wave. The first wave and its dominant follicle always appear at the same time during the cycle in all cows. In the figure, a "three-wave" cow has an estrous cycle of 21 days. Two-, three- and four-wave cycles have been observed in cattle, with the beginning of the second, third or fourth wave during the cycle being more variable than the first. Estrous cycles are longer with increasing number of follicular waves. Two-wave cycles are shorter (19 to 20 days) and four-wave cycles tend to be longer (23 to 25 days) in duration.

What determines the number of follicular waves is not yet understood. However, if a prostaglandin injection is given on day 6 or 7, for example, when the first dominant follicle is growing, the corpus luteum will regress and the first dominant follicle can ovulate and be normally fertile when A.I. breeding is performed based on heat. That would be true for any dominant follicle that is in its growing phase. It was recently demonstrated that any dominant follicle would ovulate (in the growth phase) during a normal estrous cycle if gonadotropin-releasing hormone (Cystorelin® or Facteral®) is injected, thus producing a secondary corpus luteum.

The **female sex hormone (estrogen)** also rises and falls with the growth and regression of a dominant follicle. The dominant follicle apparently dominates its subordinate peers by produc-



AN EXAMPLE OF CHANGES IN HORMONAL CONCENTRATIONS AND FOLLICULAR GROWTH that normally occur during a 21-day estrous cycle of a cow with three follicular waves.
Abbreviations: *E2 = estrogen; P4 = progesterone; LH = luteinizing hormone; FSH = follicle-stimulating hormone; luteolysis = time when the corpus luteum dies, progesterone decreases rapidly in blood; luteal = period of the cycle (days 4 to 18) when the corpus luteum is functional, progesterone is elevated, and the number of pulses of LH secretion in blood is about one per 4-6 hours; follicular = period of the cycle (days 19 to 21) when rapid follicular maturation occurs, estrogen is elevated, progesterone is low, and the number of pulses of LH secretion in blood is about one per hour.*

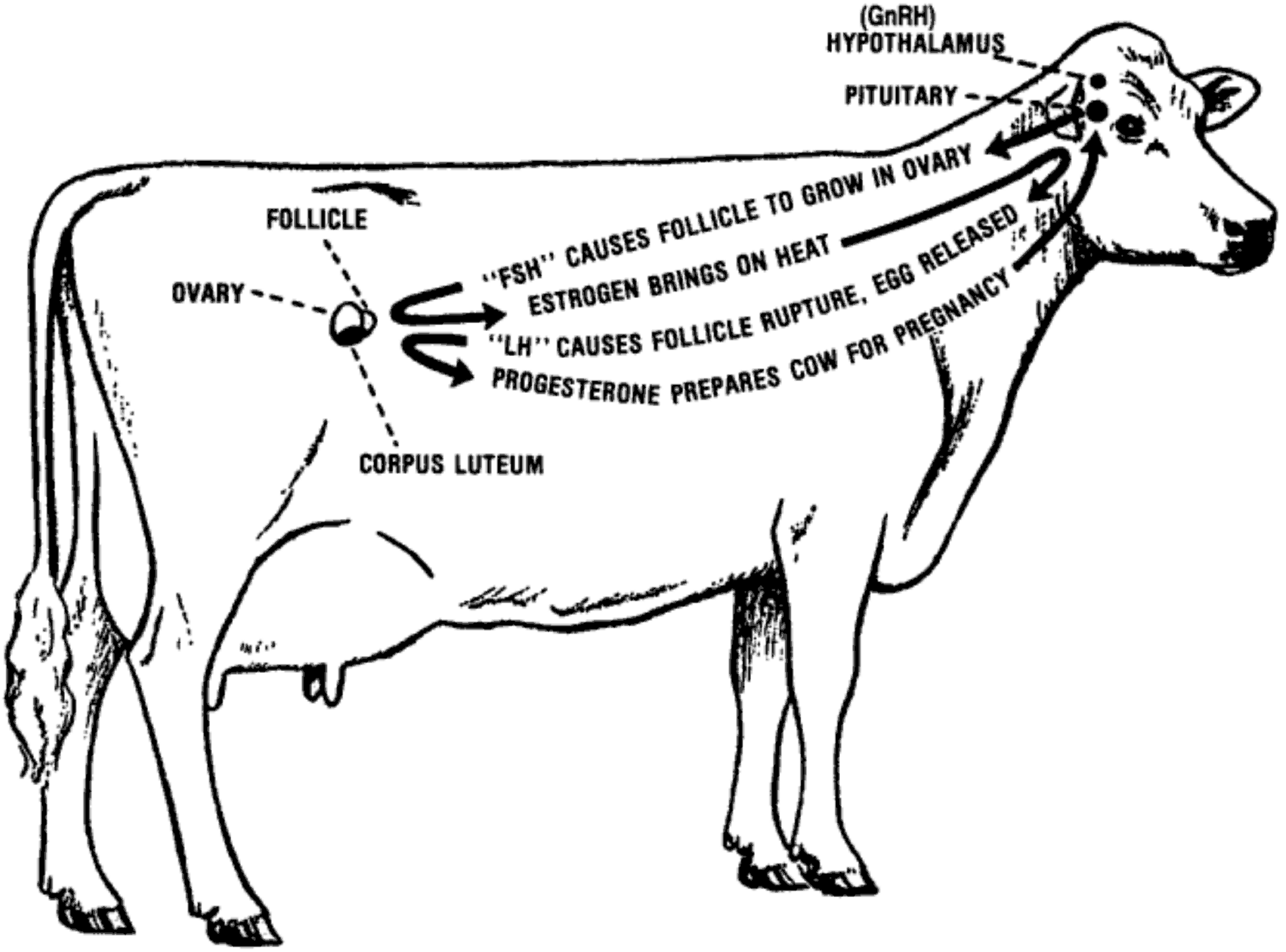
ing substances that inhibit their further growth. As it grows larger, the follicle (which is an endocrine gland itself) secretes more and more estrogen into the bloodstream. At this point, the mature follicle is about 0.75 inches in diameter. Estrogen in the blood is highest during the two days before estrus and starts to decline on the day of estrus.

Although we talk about high estrogen in blood near estrus, "high estrogen" is a bit misleading. It is high compared to other stages of the cycle. But the amount of estrogen in blood near estrus is extremely small, only about 10 parts per trillion parts of blood.

We have known about the existence of estrogen for half a century because it is such a potent chemical. However, the amount of estrogen in cows' blood is so small that it was first measured in 1971.

High estrogen in the blood has profound effects throughout the body. The most obvious effect of the estrogen is that it brings on the heat period (estrus). The behavior of the female (standing heat) is about the only reliable means we have to determine the optimum time for breeding. That people can detect heat in cows is another factor which makes A.I. breeding possible. If the bull alone could detect cows in heat, A.I. would not be practical.

Yet, it is true that some cows do not show typical symptoms during the heat period and, consequently, are less fertile simply because they are bred at the wrong time. Little is known about the manner in which


(GnRH)
HYPOTHALAMUS
PITUITARY
FOLLICLE
OVARY
"FSH" CAUSES FOLLICLE TO GROW IN OVARY
ESTROGEN BRINGS ON HEAT
"LH" CAUSES FOLLICLE RUPTURE, EGG RELEASED
PROGESTERONE PREPARES COW FOR PREGNANCY
CORPUS LUTEUM

HORMONES secreted by the pituitary gland and the ovaries control the heat cycle. About 1 day after heat, the process starts with FSH (follicle stimulating hormone) from the pituitary. This starts growth of the first wave of egg-carrying follicles on the ovary. Then the follicle secretes the female sex hormone (estrogen). No heat signs are observed because blood progesterone prevents heat. Estrogen secreted by the follicle that matures in the absence of elevated progesterone (second-, third- or fourth-wave follicle) produces signs of heat. Then the pituitary secretes LH (luteinizing hormone), which causes the follicle to rupture, releasing the egg about 10 to 16 hours after the end of heat. Then LH also causes the corpus luteum (yellow body) to replace the follicle. It produces the pregnancy hormone, progesterone. If the egg is not fertilized, progesterone secretion is terminated about 16 to 18 days later, and the heat cycle repeats.

estrogen brings on the heat period, but this effect of estrogen acts on the brain.

About one day before onset of heat, the high level of estrogen causes the pituitary to secrete more luteinizing hormone (LH). This LH causes the dominant follicle to reach its maximum size. Near the onset of heat, LH surges to about 20 to 30 times its normal level, whereas FSH secretion reaches about twice its normal concentration. The blood carries both hormones to the ovary where they stimulate the follicle to undergo changes that lead to release of the egg from within (ovulation). Normally ovulation occurs about 25 to 32 hours after the onset of heat.

If all goes well, the egg is picked up by the funnel-shaped infundibulum and directed into the oviduct. The follicle, its job done, rapidly collapses at the time of ovulation. But LH does not let these old follicle cells rest. Instead, LH causes some of these cells to grow very rapidly. Within a few days, the follicle has been replaced by a new structure, the corpus luteum (yellow body), which will be larger than the follicle (0.9 to 1.4 inches in diameter).

The corpus luteum is very different from the follicle. It is solid and dark red to yellow in color, and manufactures **progesterone**, the hormone of pregnancy. Thus, the corpus luteum is also an endocrine gland. It continues to grow larger under the influence of LH. As it grows, it produces more and more progesterone.

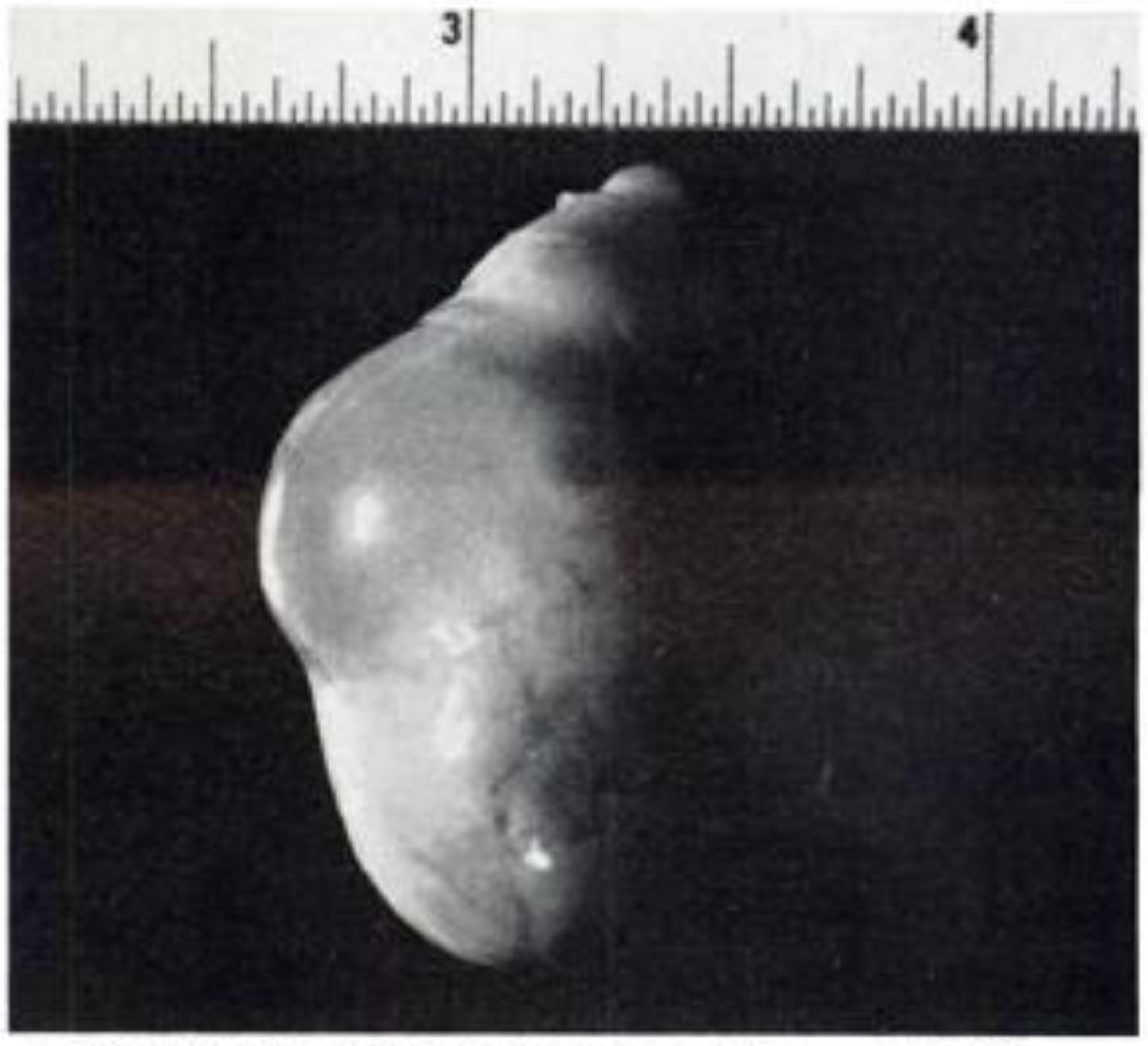
The presence of estrogen and progesterone in the blood causes drastic changes in the reproductive organs, especially in the uterus. The inside lining of the uterus grows thicker and the uterine glands become more active as the uterus prepares to nourish a new fertilized egg and start a new pregnancy.

In about half of all cows, blood may be observed on the vulva about two days following estrus. This blood is believed to be caused by the breakdown of some cells lining the uterus. It is often called a "bloody tail", and technically is known as metestrual diapedesis.

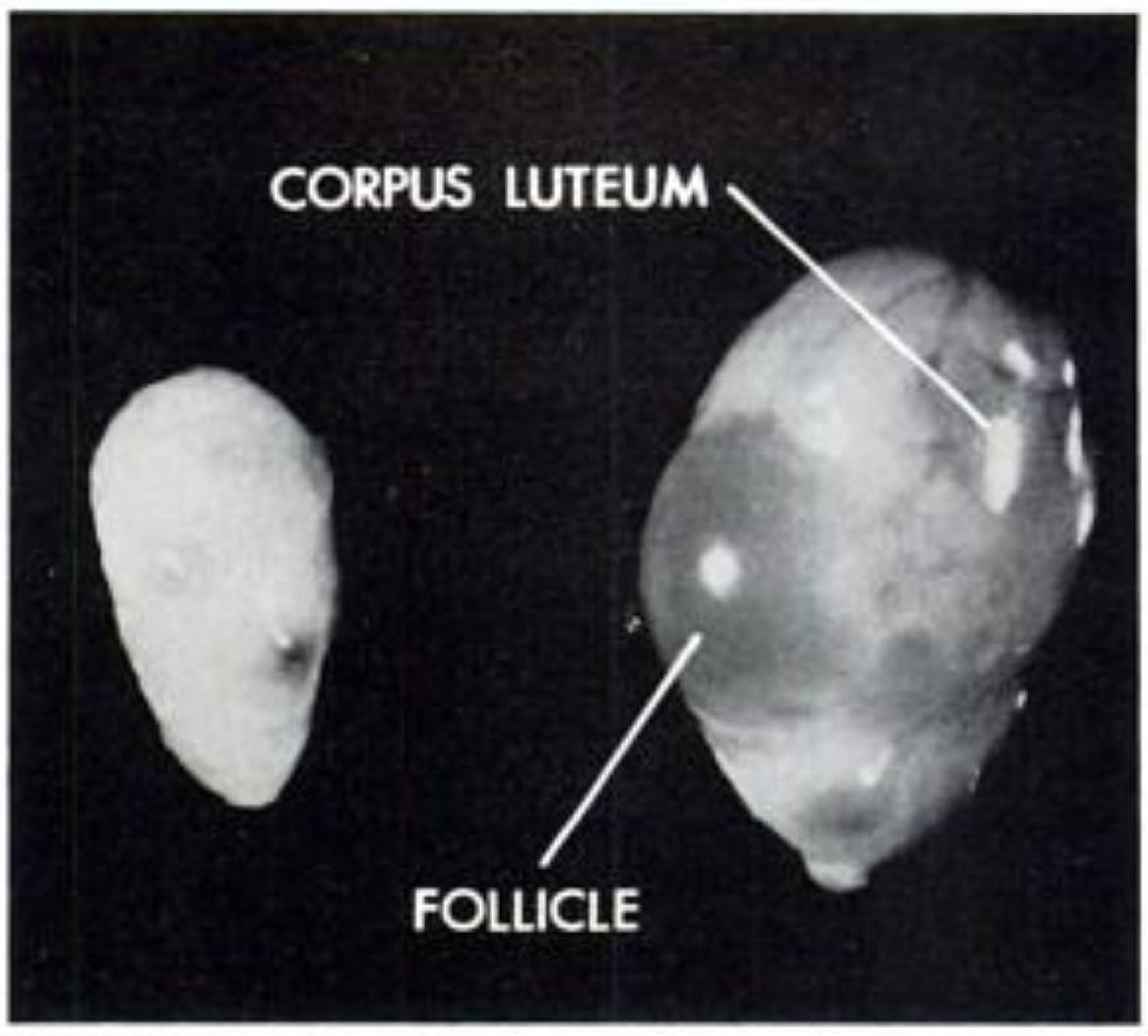
The presence of blood following estrus has no relation to breeding, injury or whether or not the cow conceived. It simply indicates the cow was probably in heat two days before.

If the egg is not fertilized, the corpus luteum grows for about 10 to 12 days and secretes high amounts of progesterone until about 16 to 18 days after estrus. High progesterone in the blood suppresses release of gonadotropins from the pituitary. During the period of luteal dominance (corpus luteum is functional and secreting elevated concentrations of progesterone), LH is secreted in pulses of one per 4 to 6 hours. This pulse frequency of LH, in combination with FSH, allows follicles to develop but not ovulate.

At about 16 to 18 days after estrus, if the cow is not pregnant, the uterus manufactures a luteolytic factor. This luteolytic factor is **prostaglandin F-2 *alpha***, a 20-carbon fatty acid. Prostaglandin travels from the uterus through the uterine vein to a point just past where the uterine vein is fused with the ovarian vein to form the utero-ovarian vein. From this point in the utero-ovarian vein, prostaglandin passes through the wall of the vein and across into the ovarian artery. The ovarian artery carries the prostaglandin to the ovary. The luteolytic factor (prostaglandin) kills the corpus luteum and the corpus luteum degenerates rapidly. As a result, progesterone falls to very low levels within 24 hours. This leads to secretion of more estrogen and LH, and causes the dominant follicle to mature. This can occur because the pulse fre-



LARGE DOMINANT FOLLICLE (blister at left) is shown on ovary. It grows in 5 to 8 days to an inch in diameter. The follicle contains the egg (ovum), that is released 10-16 hours after the end of heat.



HEIFER OVARIES 8 days after the heat period. Left ovary is presently inactive. Right ovary contains a corpus luteum (upper right) from the previous ovulation and a dominant follicle.

quency of LH secretion increases to one pulse per hour.

If all goes well, the cycle repeats every 18 to 24 days until the cow becomes pregnant.

The discovery that prostaglandin stops progesterone secretion by the corpus luteum in the cow was made in 1972. Like the hypothalamic hormones, prostaglandin was a major discovery. Anytime between days 5 and 18 after estrus, a single injection of prostaglandin causes death of the corpus luteum. Estrus occurs between 40 and 80 hours later.

Prostaglandin can be used to control the time of estrus in a cow that has a corpus luteum. It also can be used to synchronize the time of estrus in a group of animals. This will be discussed in more detail in Chapter 17.

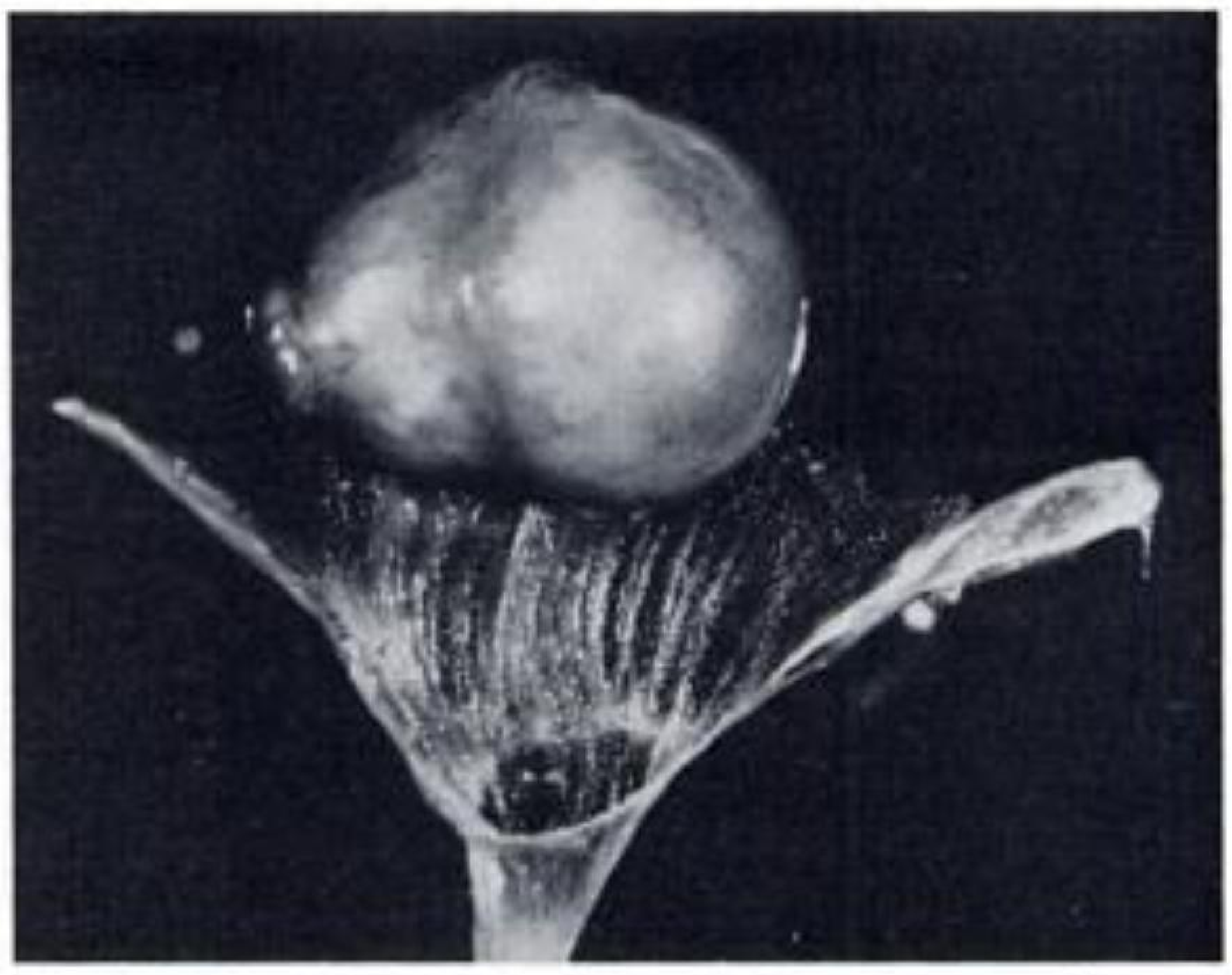
Maintain pregnancy. If the cow is bred and the egg fertilized, the corpus luteum continues to secrete progesterone. At first, the progesterone prepares the uterus for the developing calf. Later, it maintains the pregnancy, at least until the sixth or seventh month.

If the corpus luteum is removed from the ovary during the first two-thirds of pregnancy, the cow will abort. But abortion does not always occur if the corpus luteum is removed during the last third of pregnancy. The reason why cows do not always abort when the corpus luteum is removed during late pregnancy is that the placenta produces a large amount of progesterone during the last three months of gestation, thus taking over the role of the corpus luteum.

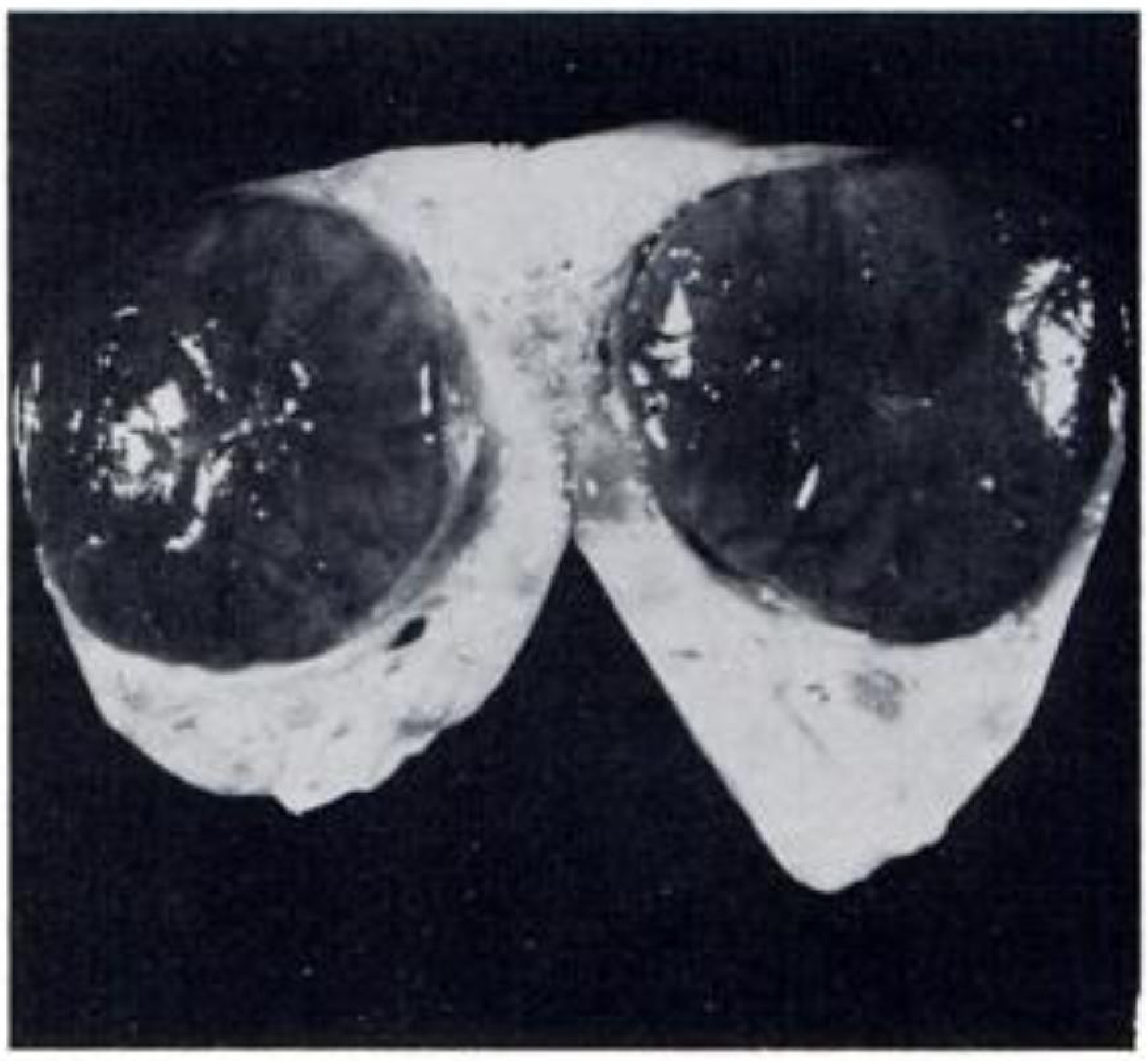
All during the estrous cycle, estrogen and progesterone have essential effects upon the udder, at least in the heifer. Progesterone causes the cells that secrete milk to multiply. Estrogen stimulates growth of the ducts that drain the milk to the teat.

These effects on the udder are very pronounced during the last few weeks of pregnancy. The placenta releases very large quantities of estrogen at this time, up to 30 times higher than the high level secreted by the follicle just before estrus. The combination of the large quantities of estrogen with some progesterone is responsible for the tremendous growth of the udder in the few weeks before calving. In addition to the effects of estrogen and progesterone, mammary growth is stimulated by placental lactogen, a protein hormone produced by the placenta.

In these respects, milking is totally dependent upon reproduction. The two are inseparable. In fact, the mammary gland of the heifer will not develop appreciably until pregnancy is well under way. Milk secretion is a part of reproduction from an academic standpoint and from a practical standpoint.



COW OVARY AND INFUNDIBULUM. Ovary has large corpus luteum (left) from previous ovulation and large follicle (right) for next ovulation. Ovary itself (top) is relatively small. Notice opening through the infundibulum (funnel).



CORPUS LUTEUM dissected open. Notice that squeezing ovary could dislodge corpus luteum.

There is still another hormone from the pituitary gland that affects reproduction. This hormone, oxytocin, is from the posterior (back) part of the pituitary; the other pituitary hormones mentioned in the foregoing are from the anterior (front) part of the pituitary. Because oxytocin was found in the posterior pituitary, it was thought for many years that the hormone was produced by that gland. However, now it is known that oxytocin is produced by the hypothalamus and is only stored in the posterior pituitary.

Oxytocin is the hormone that causes milk let-down at milking time. It also causes contractions of the uterus. At the time of breeding, either naturally or by artificial insemination, oxytocin is released from the posterior pituitary. Experimental evidence indicates that contractions of the smooth muscles in the uterus aid the transportation of sperm through the female reproductive tract to the place where fertilization occurs.

When oxytocin is released from the pituitary, it travels through the bloodstream to all parts of the body, including the udder. It is not at all uncommon to see a cow leaking milk just after palpation of the reproductive organs or breeding as a result of oxytocin causing milk letdown.

As explained in Chapter 7, oxytocin also causes the uterine contractions that expel the calf at parturition. One wonders why oxytocin does not expel the calf at milking time in pregnant cows. The reason is that the uterine muscle must be sensitized by the extremely high amounts of estrogen secreted by the placenta (up to 30 times higher than before estrus) during the two weeks before calving.

We have known for decades that it is important to be gentle with cows at milking time. The reason is that fright or stress causes the release of epinephrine from the adrenal glands. Epinephrine is a hormone that counteracts the milk letdown effect of oxytocin.

Presumably, epinephrine influences conception rate because most artificial inseminators agree that, to get highest fertility, they must treat a cow gently at time of insemination.

The two adrenal glands, one located next to each kidney, also secrete other important hormones. The chemical structures of these resemble estrogen and progesterone. Others control the rate and type of metabolism in the body. The adrenal glands of the fetus play an important role in its delivery. If the adrenal glands of the fetus are removed surgically, parturition fails to occur. The adrenal hormone responsible for this action is cortisol— a steroid hormone similar in structure to progesterone.

The nature and mode of action of hormones continue to baffle us. Our knowledge about them is very meager. In recent years we have learned how to use some of the reproductive hormones to regulate reproductive processes and reduce infertility. Some of the hormones now used to control reproduction or treat infertility problems include prostaglandin, LH, FSH, progesterone and gonadotropin-releasing hormone (GnRH)—one of the hormones produced in the hypothalamus.

Cystic ovaries. When the veterinarian palpates a cystic ovary, usually a large blister-like structure is detected which is two or three times the size of a normal mature follicle. Twelve to 14 percent of all problem breeders have cystic ovaries. Furthermore, between 10 to 40 percent of all dairy cows develop cystic ovaries during their lifetimes, and 35 to 45 percent of all dairy cows with ovarian cysts are repeat offenders.

There are three types of conditions that usually fall within the cystic ovary category—follicular, luteal, and those involving the corpus luteum. Follicular cysts are thin-walled, anovulatory (not ovulating) cysts that may occur singly or in multiples. Some cows with this type of cyst will be in heat every 3 to 5 days and may be known as "chronic bullers." However, cows with cystic ovaries more frequently fail to show any signs of heat and are termed anestrus. Follicular cysts secrete variable amounts of the hormone estrogen, which induces estrus.

Luteal cysts are also formed from follicles that did not ovulate properly. However, luteal cysts are thick-walled cysts, which secrete low levels of progesterone. Cows with this type of cyst almost always will be anestrus. Many researchers now believe that most luteal cysts were once follicular cysts that were not detected and progressed from an estrogen- to a progesterone-producing structure.

Cystic corpora lutea have characteristics similar to normal corpora lutea. They may be slightly larger and contain fluid-filled cavities of varying sizes. Cystic corpora lutea can support a normal pregnancy, and, if the cow was not bred, she will return to estrus in about 21 days despite a cystic corpus luteum. Based on recent studies of corpora lutea, the so-called cystic corpus luteum is probably a normal occurrence. Almost all corpora lutea have fluid-filled cavities during early formation. Most lose their cavity by 16 to 20 days after ovulation.

Differentiation of follicular and luteal cysts is very difficult. Because of this, a treatment which combines GnRH and prostaglandins is commonly prescribed. When GnRH is given to a cystic cow, it causes the release of large amounts of LH from the pituitary. The LH, in turn, causes the follicular cyst to luteinize or ovulate and then produce progesterone in a pattern much like a corpus luteum. However, luteal cysts are nonresponsive to GnRH. The second segment of this treatment is the administration of prostaglandin, usually 11 days later, which now can regress both cystic types. When this occurs, the cow responds by showing a normal heat within 2 to 5 days. **Improper hormones and improper amounts injected into cows can cause more problems than they cure.** Hormones should be administered only upon the advice of a veterinarian.

A few years ago, a recommended treatment for some cows with cystic ovaries was to squeeze the persistent cyst by rectal palpation until it burst or popped off from the ovary. But many people have found this procedure may result in some bleeding. This forms a blood clot around the oviduct and the fragile infundibulum. The clot frequently causes adhesions that may prevent an egg from entering the oviduct. Such a cow would not become pregnant at the time an egg was ovulated from this ovary.

Hormone injections have replaced the old method of treating cystic ovaries.

Recently, scientists have made remarkable progress in learning how to detect and measure the hormones. They have developed highly sensitive assays for hormones from the pituitary and from the ovary. These assays (radioimmunoassays or enzyme-immunoassays) have been used to study hormone secretion in normal and abnormal cows.

A management tool available to dairy producers and veterinarians is simple and rapid on-farm milk progesterone tests. Accurate and easy to use, on-farm milk progesterone tests are an important technological advance. Milk progesterone testing makes it possible to accurately monitor the reproductive status of cows—for daily reproductive management and for diagnosing herd reproductive problems. (Milk progesterone testing is discussed in detail in Chapter 13.)

Chapter 5

Union of sperm and egg

REPRODUCTIVE PROCESSES are difficult to study. Most processes take place inside the cow's body where it is very difficult to make measurements and observations. In recent years, procedures have been developed for growing and maintaining viable animal cells and tissues in the laboratory. Thus, it is now possible to study some of the early phases of development in greater detail under controlled conditions.

This chapter will describe the events leading up to the formation of a calf.

The story begins at the time of breeding, which normally should be from the middle to the end of the heat period. In natural breeding, the bull deposits the sperm in the vagina next to the cervix.

In artificial insemination, the desired site of semen deposition is through the cervix just inside the uterus in the body of the uterus. Because 10 to 20 million sperm per insemination are used in artificial insemination versus 5 to 15 billion in natural breeding, it is necessary to deposit them in the uterus.

The sperm pass into the cervix by their own motility as they are oriented against the flow of mucus from the cervix. The cervix has a very complex network of folds that function as pathways for sperm as they travel to the uterus. Because of the discharge of mucus and structure of the cervix, most of the sperm cells inseminated remain in the cervix, with only a small proportion reaching the site of fertilization.

Once the sperm pass the cervix and enter the uterus, uterine contractions become the major factor in sperm transport. The sperm swim much too slowly to move so far so rapidly. Muscle contractions of the uterus, caused by the hormone oxytocin, are responsible for a rapid transport of sperm to the oviducts.

As mentioned in previous chapters, the egg is released (ovulated) about 25 to 32 hours after the onset of the heat period. It is picked up and directed almost immediately by the infundibulum (funnel) and enters the oviduct. The egg then begins its journey toward the uterus. The first part of this journey is relatively fast. It probably passes to the middle of the oviduct within six hours.

After this time, the egg rapidly loses its viability. Consequently, if the egg is to be fertilized, it must be fertilized while it is in the upper half of the oviduct. Its fertile life is no longer than about 10 to 12 hours. Eggs may be fertilized after this time, but evidence indicates such fertilizations are likely to result in early abortions or abnormal embryos.

Sperm are transported to the oviducts within minutes after insemination; however, these have been shown to be dead sperm. The greatest number of viable sperm are found in the oviducts 8 to 12 hours after insemination, with some decrease following. **Acceptable fertility occurs when cows are inseminated about 12 to 16 hours after the beginning of standing heat.** The universally accepted time of insemination is a rule of thumb called the **A.M.-P.M. rule**. Based on watching cows twice daily, those cows first detected in heat in the morning are bred that same afternoon, and those found in the afternoon and night are bred the following morning. More exacting measures have been attempted, but the rule of thumb is as simple and successful as we have at the present time.

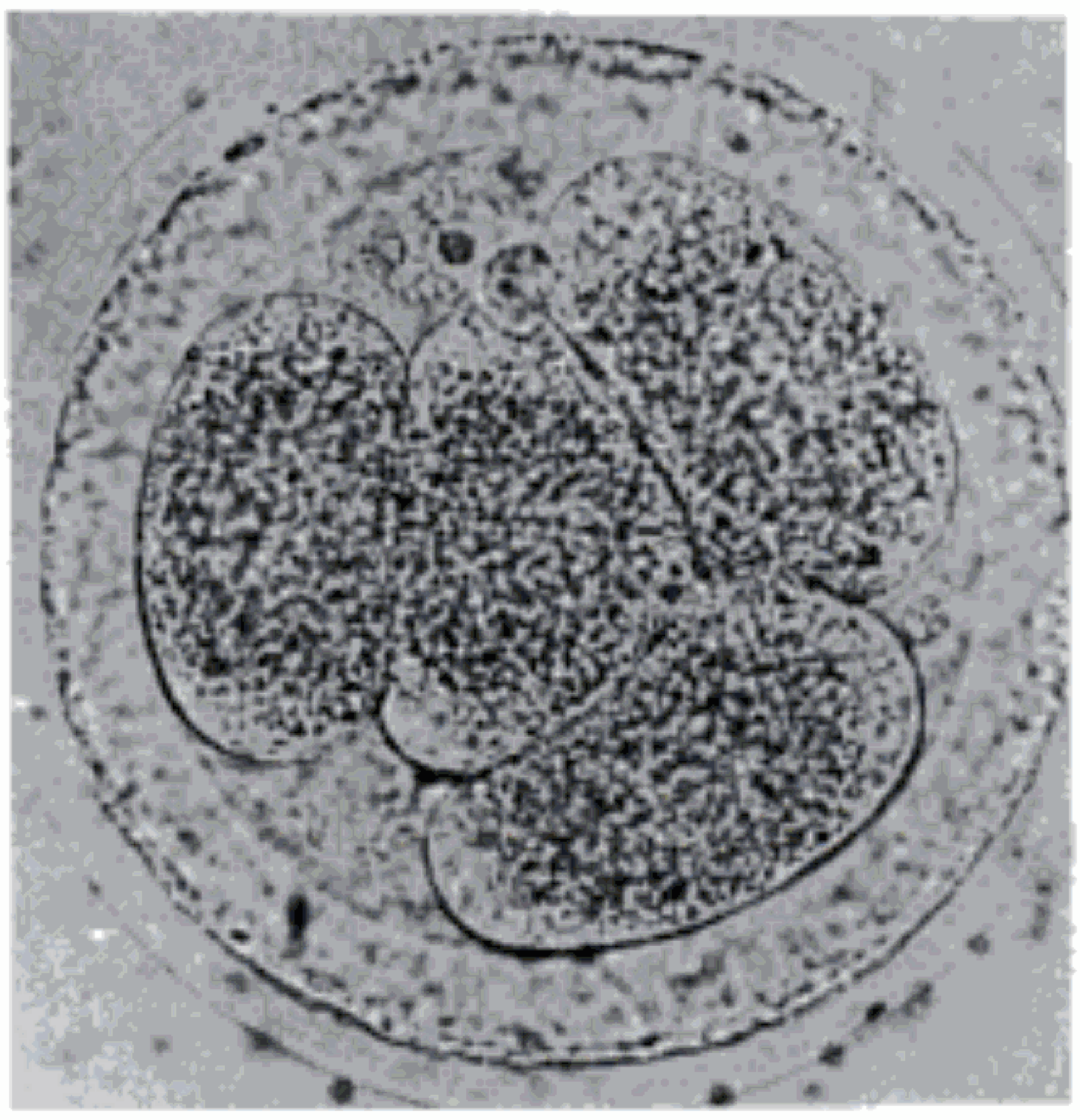
Sperm develop fertilizing capacity. Sperm apparently have to reside in the female reproductive tract for a period of time before they develop the capacity to fertilize an egg. Changes in the sperm surface take place, making enzymes available that allow the sperm to penetrate the outer surface of the egg. It may take the action of thousands of sperm cells to cause certain changes of the egg and its surrounding cells before fertilization can occur.

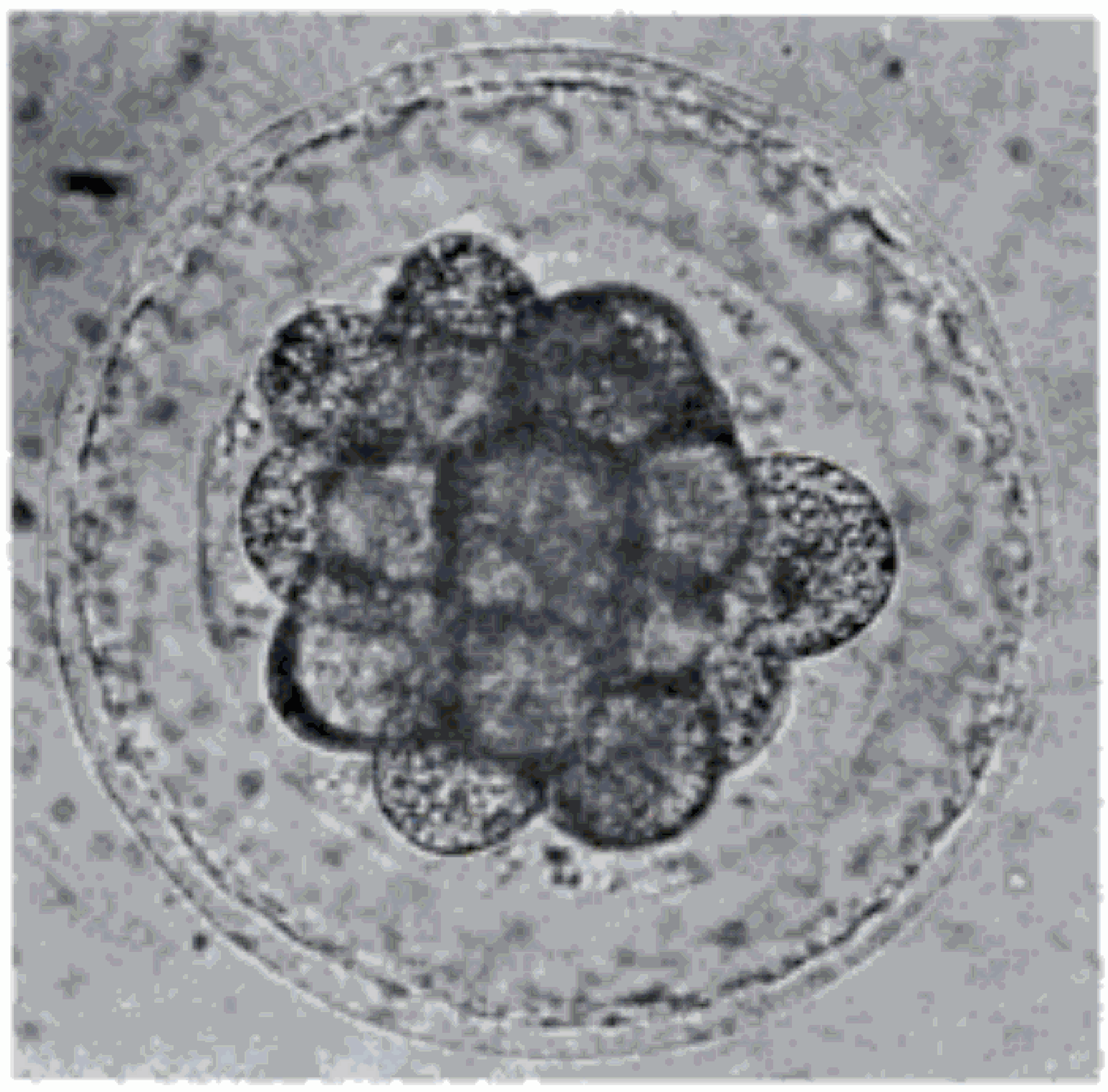
Whether from natural mating or from artificial insemination, sperm live for only about 24 hours in the female reproductive tract. In normal cows, therefore, we can expect satisfactory fertility from matings made at any time from the middle of the heat period to about 10 hours after the end of heat.

Despite this apparent wide range of time during which satisfactory fertility results can be obtained, the highest fertility is obtained when cows are bred sometime during the latter part of standing heat.

These are the reasons why A.I. technicians want to know when the cow came in heat so

FERTILIZED EGG at near right has divided two times to form four cells. It now represents a newly formed animal. Dividing cells of fertilized egg at far right total 16. All body parts of the mature animal originate from these cells. Both embryos are contained in a translucent membrane known as the zona pellucida, from which they will later "hatch" as the blastocyst develops and elongates to form the placenta and the new calf.





they can breed her at the optimum time — **before or just after she goes out of heat. Best results seem to be obtained when cows are bred near the end of the heat period.** Breeding at this time enables the sperm to become "capacitated" (have ability to fertilize the egg) when the egg is released from the ovary.

These time intervals represent averages, and many cows do not fit the pattern of the average cow. Some cows will remain in standing heat longer. Others will ovulate sooner or later after heat than the average cow.

This is one reason why accurate breeding records on individual cows are so important. For a particular cow, an abnormally long heat period might be "normal." Accurate records with this type of information provide valuable assistance for timing the insemination.

Our present understanding of the fertile life of the egg and sperm, and the need for sperm capacitation explain why proper timing of the insemination is so important in obtaining optimal fertility. If cows are inseminated too early, the sperm may die before the egg is released. If cows are inseminated too late (after ovulation), the egg will become infertile before the sperm gains the ability to fertilize the egg.

Provided insemination was made at the right time, fertilization occurs within four to six hours after ovulation; that is, about 29 to 36 hours after the onset of the heat period. The actual process of fertilization baffled scientists 70 years ago. And it still does!

When sperm reach the upper half of the oviduct, the site of fertilization, they begin their search for the egg. Motility of the sperm probably is important in this search, although contractions of the oviduct undoubtedly help the sperm.

The sperm cell is much smaller than the egg.

Its length, including the tail, is about the same as the diameter of the egg. The process of fertilization is not clearly understood. Several sperm cells may penetrate the outer layer of the egg (zona pellucida). But under normal circumstances, only one sperm cell passes through the egg membrane. This occurs because some change in the chemistry of the membrane blocks entry of any additional sperm after the first one has penetrated this layer. Exactly how this penetration occurs is still debated. But most evidence suggests that one membrane on the sperm fuses with the egg membrane and the entire sperm is then engulfed into the cytoplasm of the egg. The sperm nucleus is released and then unites with the egg cell nucleus. Under some abnormal conditions, more than one sperm may fertilize the egg. Apparently these genetic freaks are lost very early in pregnancy.

Speaking exactly, the union of the sperm nucleus and the egg nucleus is **fertilization.** The nucleus of the sperm and egg contains the hereditary information (chromosomes) which is passed on to the new offspring. These bits of hereditary information are contained in genes located on the chromosomes in the nucleus. The chromosomes become paired (one from each parent) as the two nuclei (of the sperm and egg) join. The sex and inherited features of the new calf are determined at this time.

One-celled calf. The newly fertilized egg is now a one-celled calf (conceptus or zygote). This one cell possesses the inherent ability to divide first into two cells, then into four cells, and so on until it reaches the countless numbers of cells that make up the various parts of a calf.

The cow has now completed only one phase of her tremendous task in reproduction. She has produced a viable egg and provided the environment for fertilizing the egg. Next, she must carry and nourish the developing calf during the nine months of its intrauterine life. Later she must give uncomplicated birth to the calf.

Chapter 6

Before birth

A calf begins to grow

THE REPRODUCTIVE PERFORMANCE of the cow has become so well accepted that we seldom give serious thought to what actually goes on inside her body. The cow is expected to produce a fertile egg and provide a favorable environment for sperm cells to fertilize the egg.

In addition, she must carry and nourish the developing fetus and then give birth to a normal, healthy calf. And all the time she is assisting nature in creating a new life, she is expected to pay for her keep by producing tremendous quantities of milk.

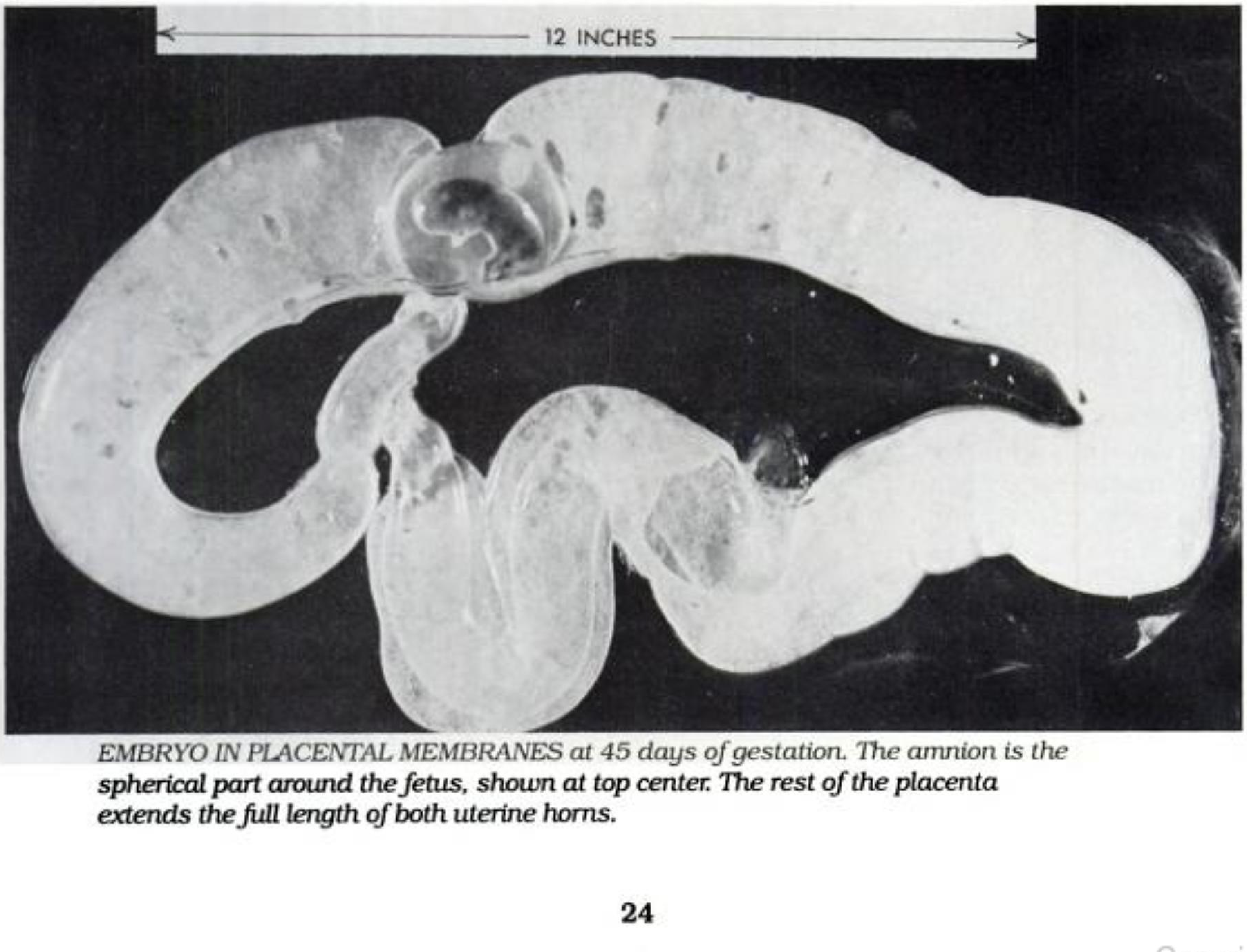
In the previous chapter, we discussed how the sperm cell and egg get together to accomplish fertilization. This process is the very beginning of new life!

The fertilized egg divides the first time within about 20 hours. Each of the two resulting cells divides again to form four cells within another 30 to 40 hours. By this time, the developing conceptus has descended into the lower half of the oviduct. The cells, still within the zona pellucida, continue to divide while the conceptus stays in the lower half of the oviduct for about two additional days. At the end of this time, the conceptus contains 8 to 16 cells.

Transport of the conceptus down the oviduct is believed to be controlled by the hormones estrogen and progesterone. However, the exact mechanism is not known. If muscular contractions of the oviduct are responsible, we do not understand how similar contractions could transport sperm up the oviduct at one time and then propel the fertilized egg down the oviduct just three days later.

At the end of these three days, the developing embryo is about the size of a pinhead.

The junction between the oviduct and the uterus is responsible for holding the conceptus in the oviduct for as long as three days. During this time, the corpus luteum is growing and secreting more and more progesterone (the pregnancy hormone). When the progesterone balances



EMBRYO IN PLACENTAL MEMBRANES at 45 days of gestation. The amnion is the spherical part around the fetus, shown at top center. The rest of the placenta extends the full length of both uterine horns.

the residual estrogen (female sex hormone) in the bloodstream, the tubo-uterine junction opens and allows the conceptus to pass into the uterus.

The three-day stay of the conceptus in the oviduct is important. Apparently, it takes about this long for the progesterone to prepare the uterus so that it can provide a suitable environment for the conceptus.

Once the conceptus, or embryo, enters the uterus, the cells within it divide rapidly and accumulate at increasing rates. The dividing cells remain so within the zona pellucida for about 8 to 9 days. Then this outer membrane of the egg breaks open and the cells begin to push outward (hatching). At first, layers of cells are formed and this is followed by the formation of the body organs and body parts. For example, the heart begins to beat as early as 22 days after fertilization.

For about 25 days, the developing embryo floats rather freely in the lumen of the uterus. During this time, it must absorb its nutrients largely from fluids (uterine milk) within the uterus.

While the embryo is floating freely in the uterus, membranes grow around it. When the embryo is about 25 days old, the membranes from the embryo begin to unite with the caruncles (buttons) on the inside lining (endometrium) of the uterus. This forms the placenta.

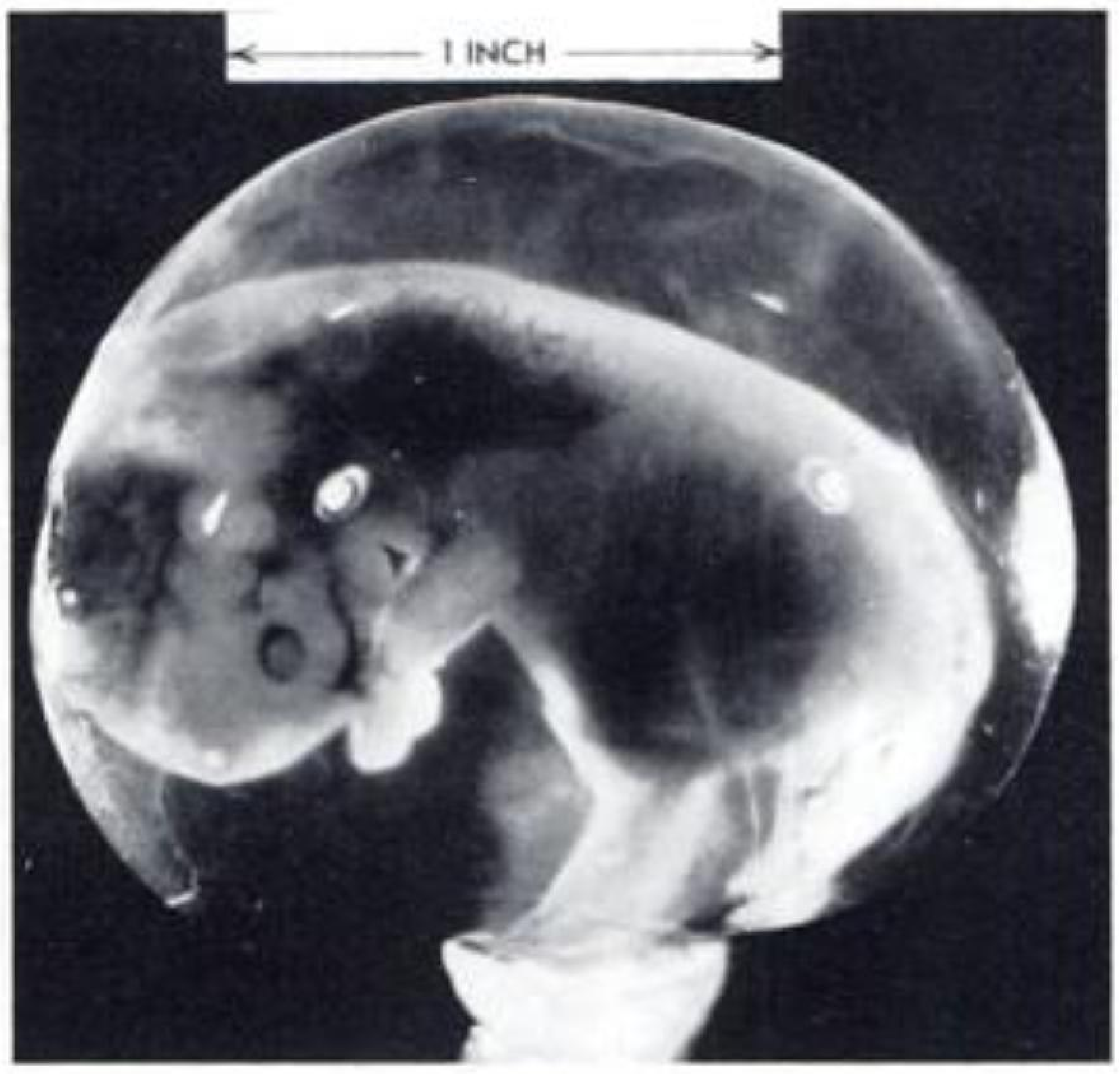
The spaces between the membranes of the placenta become filled with fluid. Actually, the calf develops inside a fluid-filled sac, called the amnion, which is enclosed by another fluid-filled sac, called the chorioallantois. The fluid distributes the force of any blow over the entire surface of the calf and thereby protects it.

When the embryo is 35 to 45 days old, the head and legs are recognizable. Blood vessels begin to grow out from the heart of the fetus. A large artery and vein grow through the umbilical cord, pass through the placental membranes, and end in microscopic capillaries in the cotyledons on the placental surface.

Where the placenta contacts a uterine caruncle, a cotyledon (button) develops. The placenta is attached to the uterus by those caruncular-cotyledonary unions, known as placentomes. The caruncle and cotyledon attach together much like velcro. The cotyledons have microscopic-sized, finger-like projections which, by this time, have grown into the caruncles on the uterus. Blood vessels from the cow end in microscopic capillaries in the caruncles. The maternal capillaries in the caruncles lie very close to the fetal capillaries in the cotyledons.

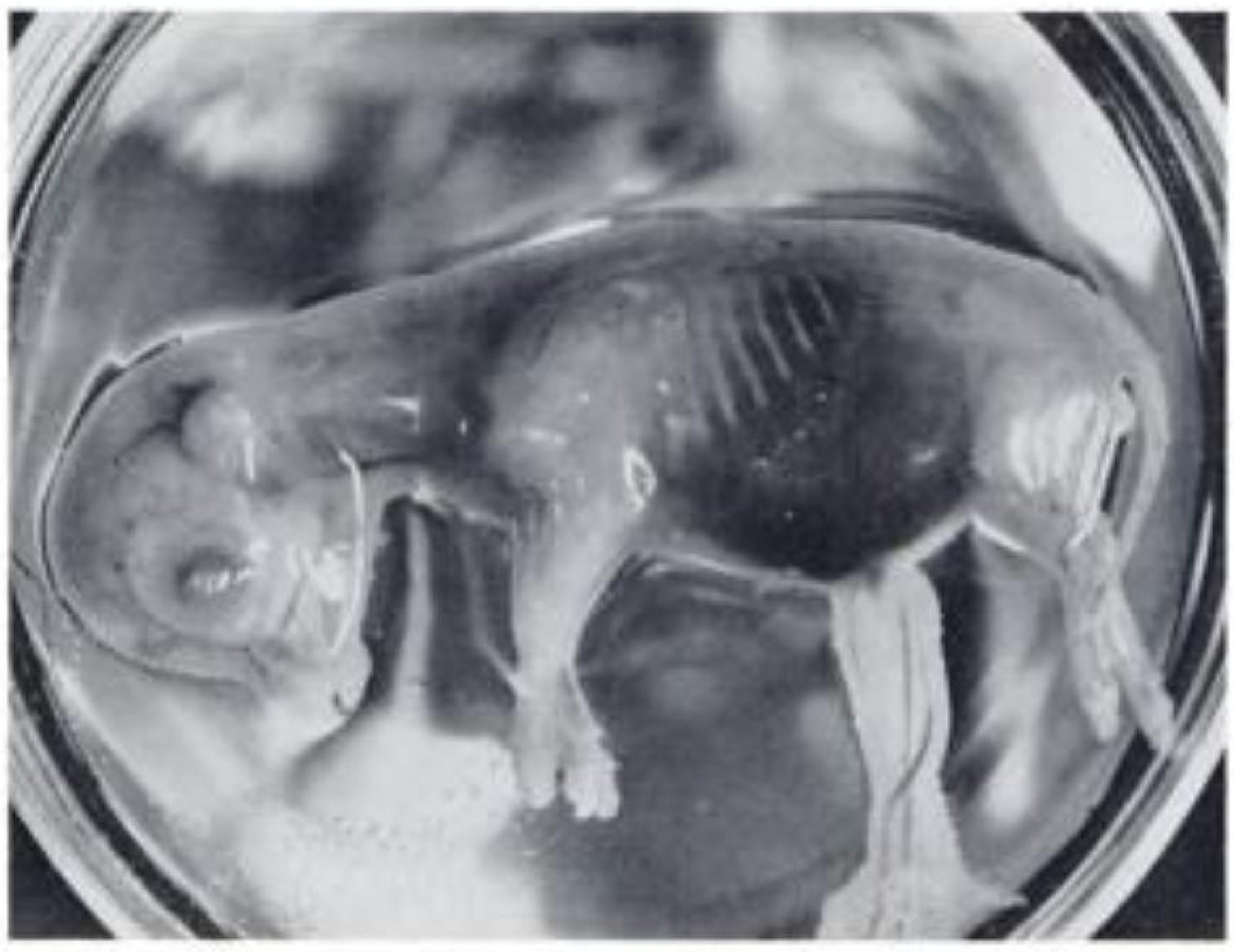
This intimate association between the fetal and maternal blood systems enables nutrients and gases to diffuse from the cow's blood into the bloodstream of the fetus. Waste products from the fetus diffuse into the bloodstream of the dam where they are eliminated. In this manner, the mother "feeds" the fetus and voids the waste products from it. **There is no direct connection between the blood vessels of the cow and those of the calf.**

By 60 days, most of its adult organs have been formed, although, by no means, are all of them functional. From this time on, the new calf is known as a fetus. By the time it is 90 days old, it may be clearly recognized as a calf.



EMBRYO IN THE AMNION, the membrane that immediately surrounds the developing calf. There is another outer membrane (chorioallantois) that has been dissected away. The two membranes and fluids inside them protect the calf in the uterus and form the placenta, or afterbirth.

Then comes the period of most rapid skeletal growth in the whole life of an animal. The fetus gains from about 2 pounds to a birth weight of 50 to 90 pounds during the last five months of pregnancy.



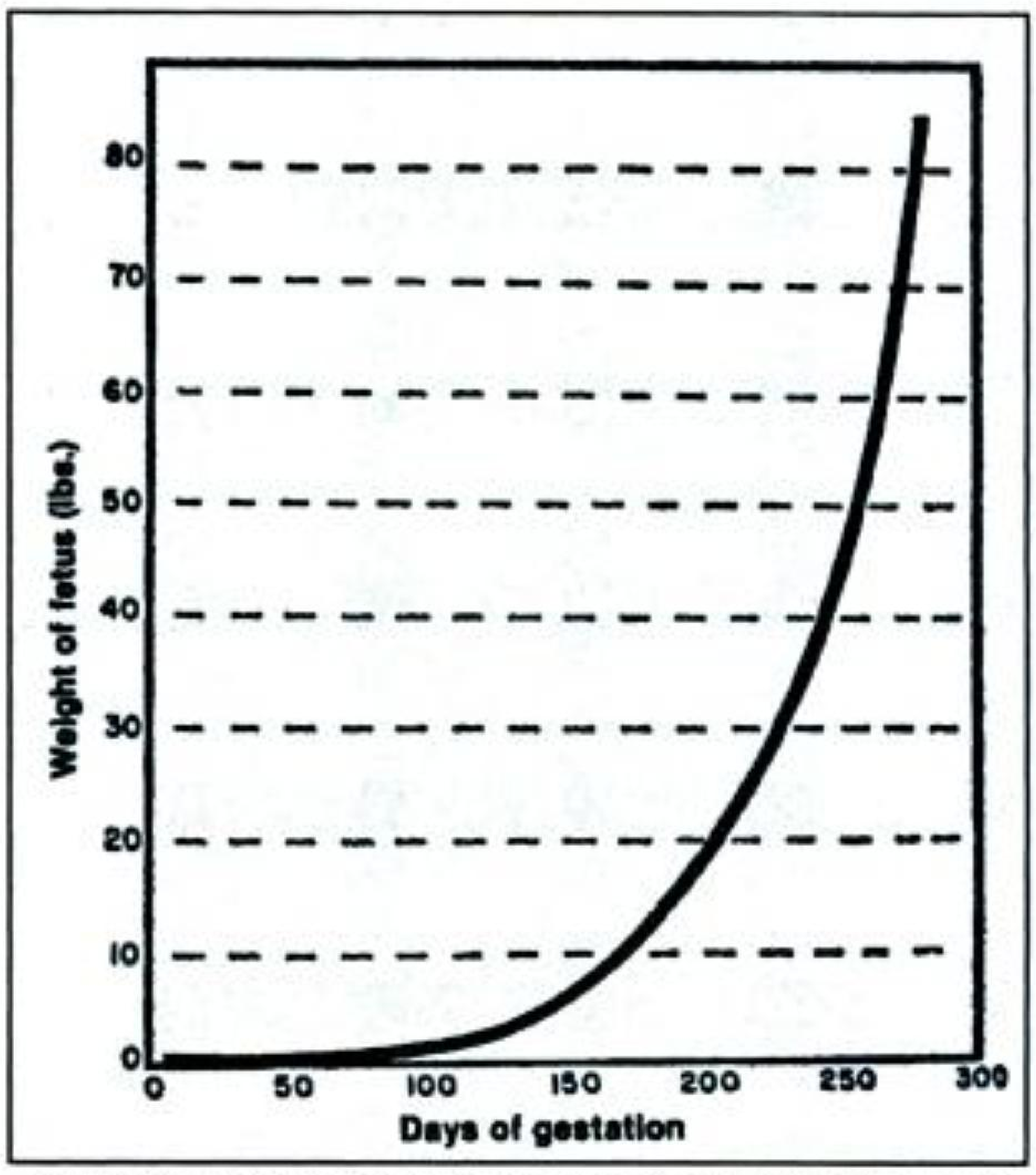
THIS 60-DAY-OLD FETUS was removed from a cow. It measures about 3 inches long. A growing calf represents the successful conclusion of thousands of intricate events during normal reproduction.

The birth weight of the calf largely is determined by the size of the cow and by heredity. The effect of heredity is evident in the average birth weights for the different breeds, which vary from 50 to 90 pounds. It is interesting that all mammals, from the mouse to the elephant, are about the same size when life begins with the fertilized egg.

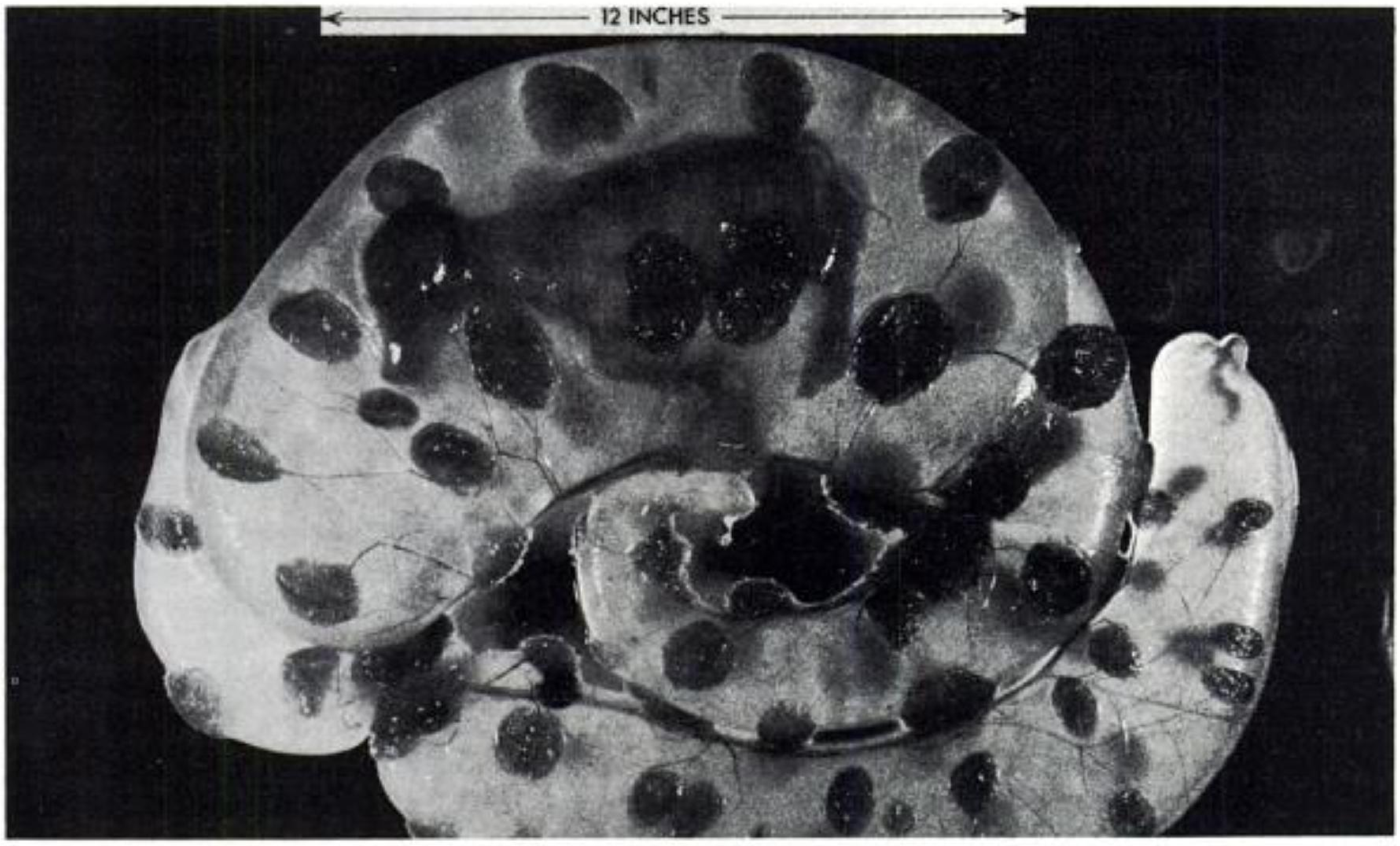
Hormones necessary for birth. After the fetus is about 8 months old, drastic changes begin to occur in the cow. Progesterone secretion from the corpus luteum begins a gradual decline. At about this same time, the ovary begins to release another hormone, known as relaxin. Relaxin prepares the cow for calving by softening and relaxing the tissues that make up the birth canal. The cervix, for example, has been closed very tightly all during pregnancy to keep foreign material out of the uterus. But now the thick mucus making up the cervical plug liquifies, and relaxin softens (relaxes) the cervix so it can dilate and expand enough to allow the calf to pass through.

The calf plays the key role in its own delivery. Although the exact mechanism that starts the whole process is unknown, it is thought that maturation of the calf's hypothalamus is involved. Presumably the "matured" hypothalamus stimulates the pituitary to secrete adrenocorticotropic hormone (ACTH), which in turn stimulates the calf's adrenal glands to secrete more corticosteroids.

The corticosteroids from the adrenal glands stimulate the placenta to secrete large quantities of estrogen—much larger



GROWTH OF THE FETUS is illustrated in this graph. The calf is still very small at 50 days. But the rate of growth increases rapidly as pregnancy progresses to the calving date.



FETUS IN PLACENTAL MEMBRANCES at 4 months of gestation. The amnion (immediately surrounding the fetus) is bean-shaped and about 18 inches long. Blood vessels radiate from cotyledons on the surface of the placenta toward the umbilical cords of the fetus.

quantities than are secreted at estrus. The large amount of estrogen makes the uterus more sensitive to other hormones that stimulate contractions of the uterine muscles.

As the estrogen levels rise rapidly, they stimulate the uterus to secrete prostaglandin.

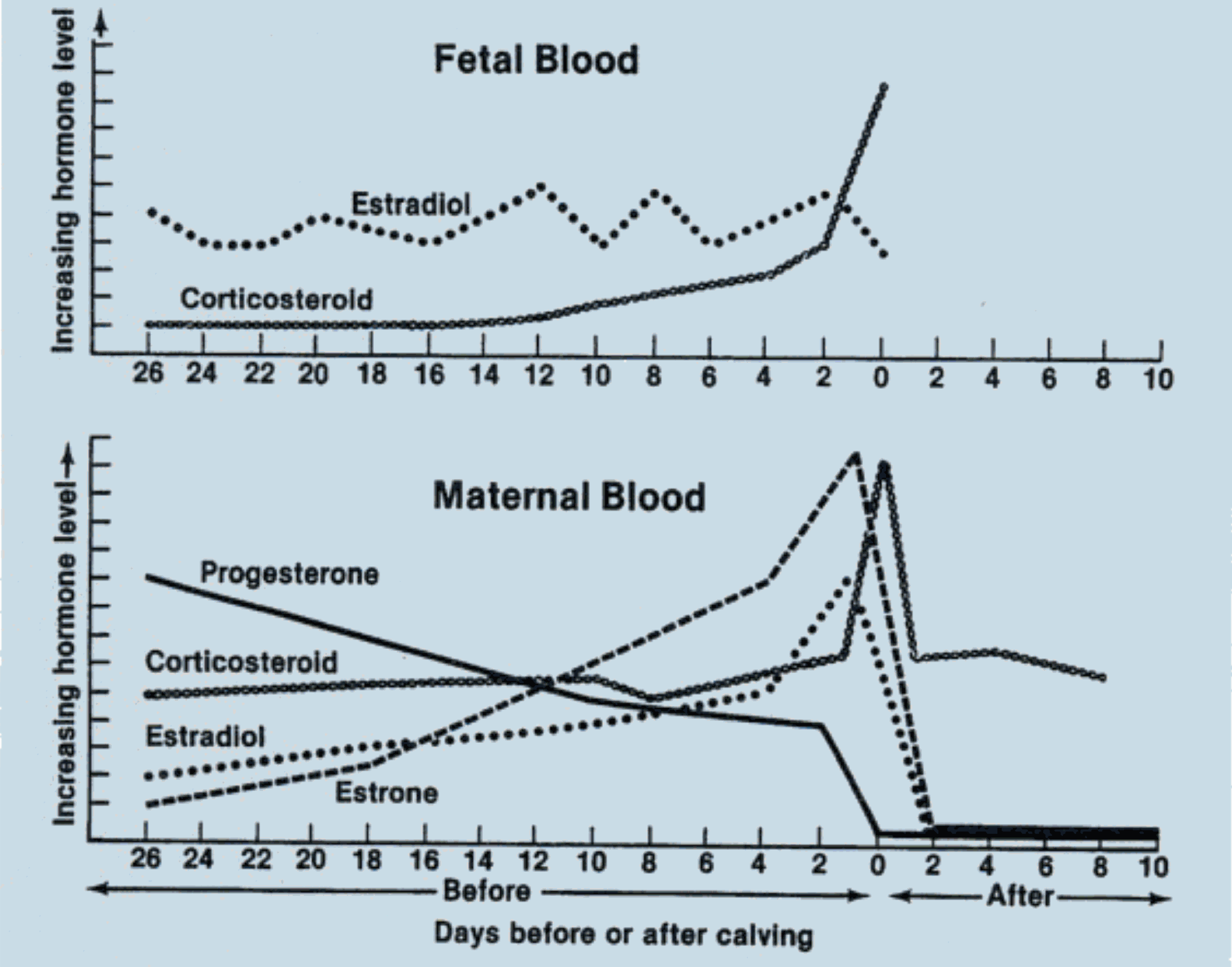
Prostaglandin plays two roles. It causes regression of the corpus luteum just as it does near the end of each estrous cycle, and it stimulates uterine contractions. At this same time, increased prostaglandin causes oxytocin release from the posterior pituitary. Together, prostaglandin and oxytocin cause uterine contractions leading to birth of the calf.

During the beginning stage of labor, the fully developed calf is pushed into the normal birth position. The forelegs are extended with the head lying on them ready to pass through the dilated cervix.

In any other position, the calf is likely to cause difficulties for the cow. The young calf is usually born free of its surrounding membranes. Because the umbilical cord is short, it usually breaks as the calf is dropped. Thus, the calf must start breathing and begin its independent life in a new environment.

We have the expertise in this country to land a man on the moon, but no one knows how a sperm fertilizes an egg to initiate a new life. This comparison illustrates the intricate nature of the formation and development of a calf.

Infertility can originate at almost any point in the development of the calf. This infertility easily may result in the death of the calf. But in the long run, the possibility of permanent damage to the cow's reproductive tract may be even more serious.



CHANGES IN CONCENTRATION OF SELECTED HORMONES in the blood of the calf (top) and cow (bottom) around the time of calving. Each hormone is shown relative to the changes that occur for it alone. Actual levels may vary more than 100-fold for the hormones shown, so direct comparison should not be made among different hormones.

Beginning about 2 weeks before delivery, fetal corticosteroids increase, and this stimulates an increase in placental estrogens (estrone and estradiol) in the cow. Corticosteroids in the calf and cow, and estrogens in the cow peak around the time of delivery. In contrast, progesterone from the placenta and the cow's corpus luteum declines slowly until 1 to 2 days before delivery when it decreases rapidly. Not shown is an increase in prostaglandin F2-alpha in the cow's blood during 1 to 2 days before delivery and a simultaneous increase in prolactin from the pituitary gland that initiates milk secretion.

(Adapted from Beltsville symposia in Agricultural Research, 3, Animal Reproduction, Allanheld, Osmun and Co., publishers)

Chapter 7
It's calving time!

A FARMER may fertilize the soil, choose the best variety of seed corn, plant the seed at the appropriate depth in a properly prepared seedbed, and suitably cultivate the growing plants, but if the corn is not harvested properly, most everything that preceded the harvest is wasted.

Similarly, a dairy producer may breed the cow at the correct time with good-quality semen from the best bulls, and provide adequate nutrition and a healthy environment for the cow and growing fetus, but if one neglects to care for the cow at the time of calving, the calf may not survive.

Equally serious, bad management at calving time may result in the loss of the cow or in permanent damage to her reproductive tract. Following are some causes of infertility that arise at the time of calving and some management practices to help avoid them.

Length of gestation. Gestation begins at fertilization and ends at birth. For practical purposes, however, the time of fertilization is difficult to measure. Consequently, most dairy producers use the time of insemination as the beginning of gestation.

The duration of gestation varies with age and breed of the cow, sex of the calf and number of calves carried. Probably the season of the year and inheritance also affect gestation length.

Surveys of all breeds of cattle generally show average gestation lengths of 276 to 292 days. Bull calves are carried about one day longer than heifers. Twins usually are born about a week earlier than single calves.

Symptoms of approaching birth. As calving time nears, the ligaments around the tailhead and pelvis relax and sink. When the tendons and muscles relax, producing a hollow appearance on either side of the tailhead, calving may be expected within two or three days. The vulva swells and mucous discharges are common. Presumably, these changes are caused by an increased secretion of the hormones estrogen and relaxin.

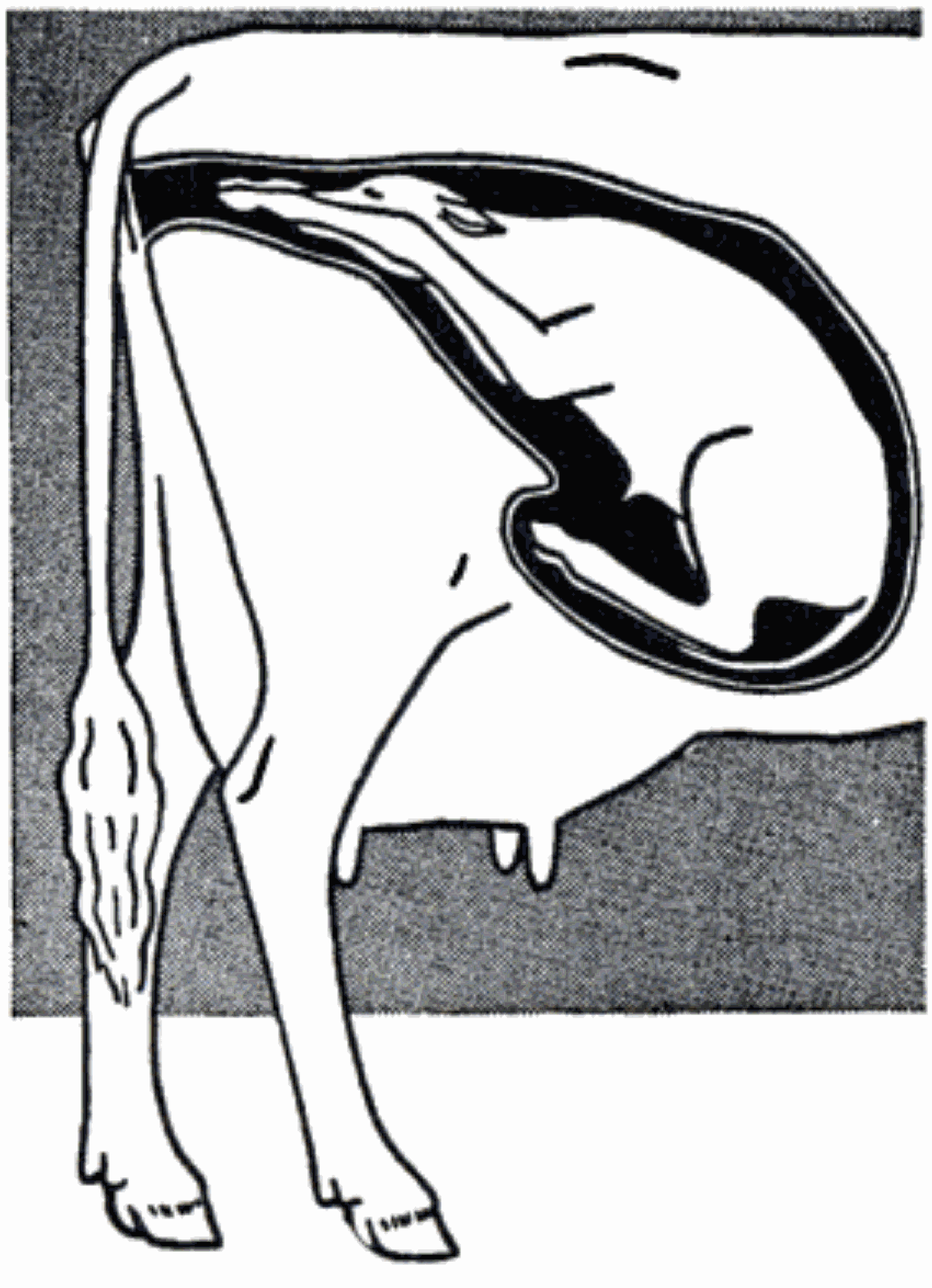
Simultaneously, the udder rapidly becomes distended. In many cows, especially heifers calving for the first time, considerable udder edema (swelling) develops, which may extend under the stomach as far as the brisket. The edema is due to temporary blockage of the lymph vessels from the udder. Moderate exercise (turning cows out-of-doors twice daily) may help con-

trol it. In extreme cases, your veterinarian may prescribe a diuretic to help void the excess fluids.

When these symptoms appear, the cow should be isolated—placed in a straw-bedded box stall that has been scraped, washed with soap and water, disinfected and allowed to dry for at least 24 hours. Clean, dry quarters are important to the health of the calf and cow at this time.

If the weather permits, another good site for cows to calve is a grassy pasture near the barn. The pasture should be clean and free from contamination.

The normal calving process is slower for heifers than for cows. A cow may spend two to six hours preparing for calving, whereas a heifer may require up to 10 hours. The actual time for expulsion of the calf is usually no more than one-half to 2 hours.



NORMAL BIRTH POSITION of the calf. The calf lies on its stomach with its forelegs extended and its head lying on them. In this way, the calf attains its smallest diameter.

Shortly before birth, the uterus begins contracting, mildly at first. This may go on for as long as 24 hours (average of about four hours), during which time the cow becomes increasingly restless. The fetus is pushed against the cervix, causing it to dilate (open). Also, during this time, the fetus is oriented in its proper birth position, lying on its stomach with forelegs extended and head resting on forelegs.

Powerful contractions of the uterus then begin and these are aided by voluntary contractions of the stomach muscles. The result is that the fetus normally is pushed through the birth canal within a few hours. As the calf's head passes out of the vulva, it curves downward. This helps the hips and hind legs of the calf to extend back and pass through the pelvis more easily.

The size of the calf at birth is usually larger than the diameter of the pelvic girdle. Therefore, even with expansion of the pelvis, the normal birth position is needed because it allows the calf to assume the smallest possible diameter.

The cow should be watched closely as calving time approaches (observed at least every two to three hours) but left strictly alone unless some assistance obviously is essential. As a rule, the calf will be born within an hour after the front feet begin to show through the vulva. If the calf has not been born after an hour or two, an examination should be made.

If the condition and position of the calf are normal, the cow may be assisted by pulling on a chain attached carefully to the forelegs of the calf. Pull **downward** rather than straight out from the cow. Pull very carefully and **only** when the cow strains.

Birth. The birth process should be completed very soon after the calf's body enters the pelvic canal of the cow. Entry into the pelvic canal might shut off the blood flow through the umbilical cord, and the calf may die within minutes unless the birth process is completed.

We recommend dairy producers assist only when the birth position of the calf appears normal.

Strict sanitation is of utmost importance when assisting the birth of a calf. Clean, warm water with a disinfectant added should be used to wash the vulva and surrounding area of the cow. The person should clean his hands and arms thoroughly and wear disposable plastic sleeves.

Abnormal presentations occur in about 5 percent of the births. If the calf is oriented in any position other than normal or any other abnormal condition exists, call a veterinarian at once.

Many times the first sign of an abnormal position is when only one foreleg or a hind leg protrudes. Other abnormal conditions that require assistance include appearance of front feet with no head, appearance of the head or tail with no feet or one foot from each twin.

Other times the cow may be in labor for 24 hours or more without success. Frequently, the veterinarian must reposition the calf before it can be delivered. If the position cannot be corrected so the cow can complete delivery herself, a Caesarean operation may have to be performed, or the veterinarian may dismember and remove the calf in pieces to save the cow.

In normal delivery, the fetal membranes usually rupture about the time the forelegs pass through the vulva. The calf is delivered free of the fetal membranes, which are still tightly attached to the caruncles of the uterus to insure an oxygen supply during birth.

The umbilical (navel) cord usually breaks as the calf passes through the vulva. At this time, the calf must begin breathing since it can no longer obtain oxygen from the cow.

Care of the newborn. The newborn calf represents the primary product, and prompt attention must be given to the calf at "harvest" time. Oxygen is the first requirement to assure survival of the calf. Make certain that the nostrils are clear of membranes and fluids. Breathing may be stimulated by blowing in the nasal cavity or tickling the nasal cavity with a straw.

Undoubtedly, the most important factor in promoting calf survival is feeding colostrum within two hours after birth—the sooner the better. Colostrum is essential to get calves off to a good start. It provides a rich supply of nutrients; helps in activating the digestive system; and, most importantly, it provides protection against infection and disease.

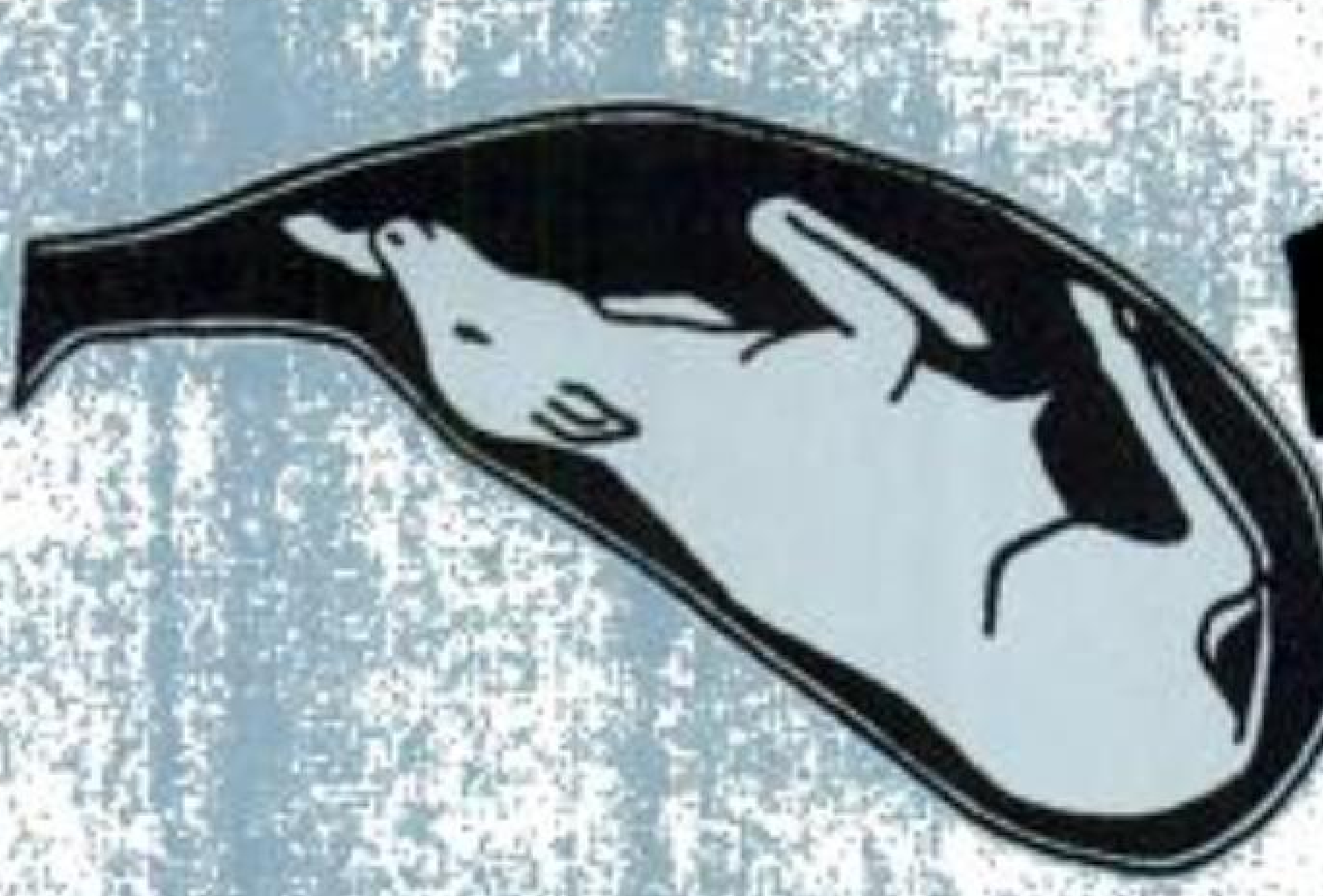
In fact, colostrum provides the only source of protection (called passive immunity) for the calf against disease-producing organisms for about the first two months of life, while the calf's own immunological defense system (called active immunity) is developing.

Intact antibody proteins in colostrum can be absorbed through the intestine only for the first few hours of life. Actually, the ability to absorb antibodies diminishes after the calf is two hours old. Thus, it is extremely important to get colostrum into calves within two hours after birth and **preferably within 15 minutes.**

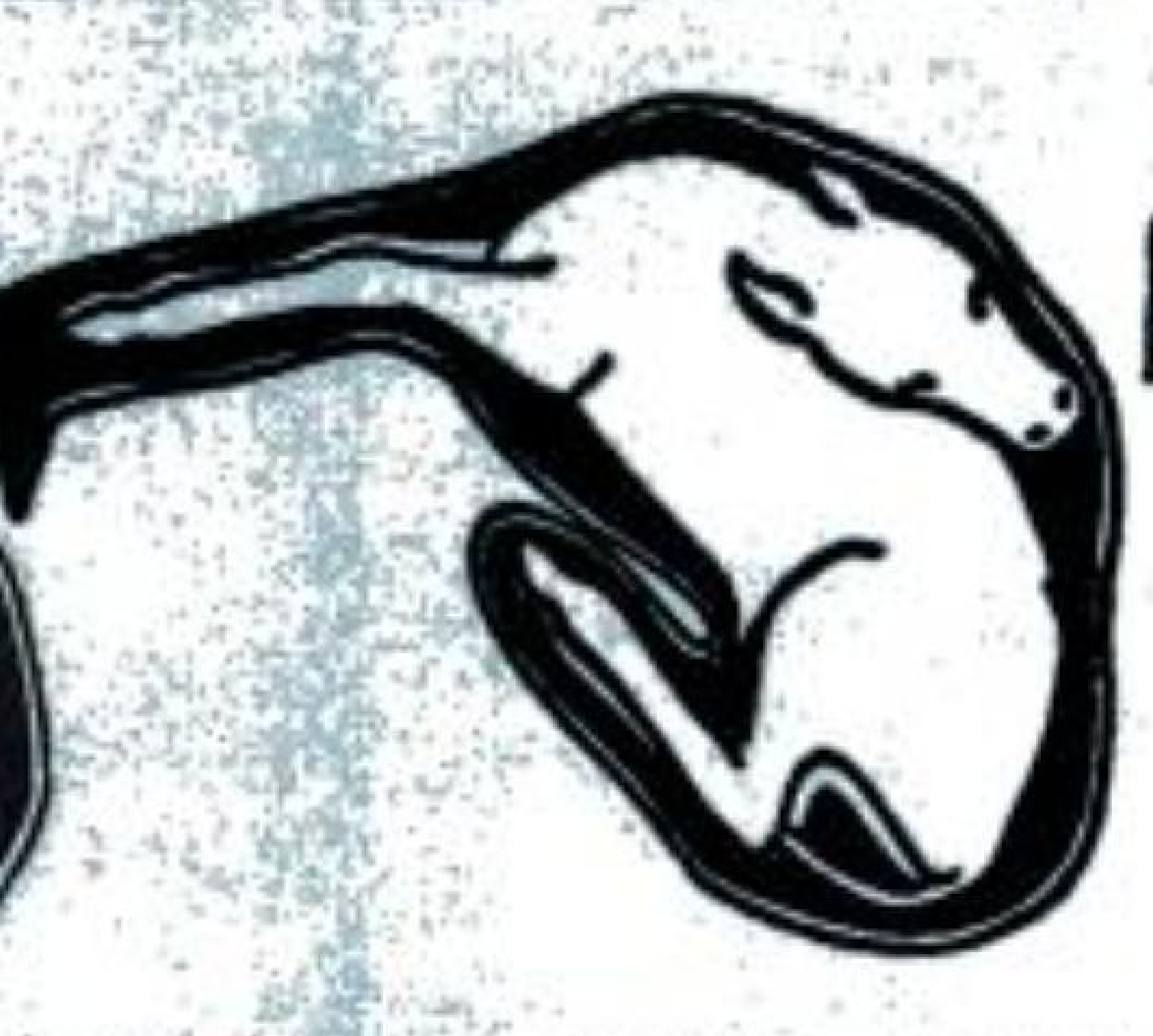
The first two weeks of life are the most critical period for calf losses. Certainly, prompt feeding of colostrum, sanitation, good housing and adequate nutrition will help get the calf off to a good start in its own environment.

Expulsion of the afterbirth. After the calf is born, uterine contractions continue, which expel the fetal membranes from the uterus. This is the afterbirth. It should be disposed of as soon as expelled. From natural instinct, cows will eat fresh membranes and may choke or have digestive disturbances.

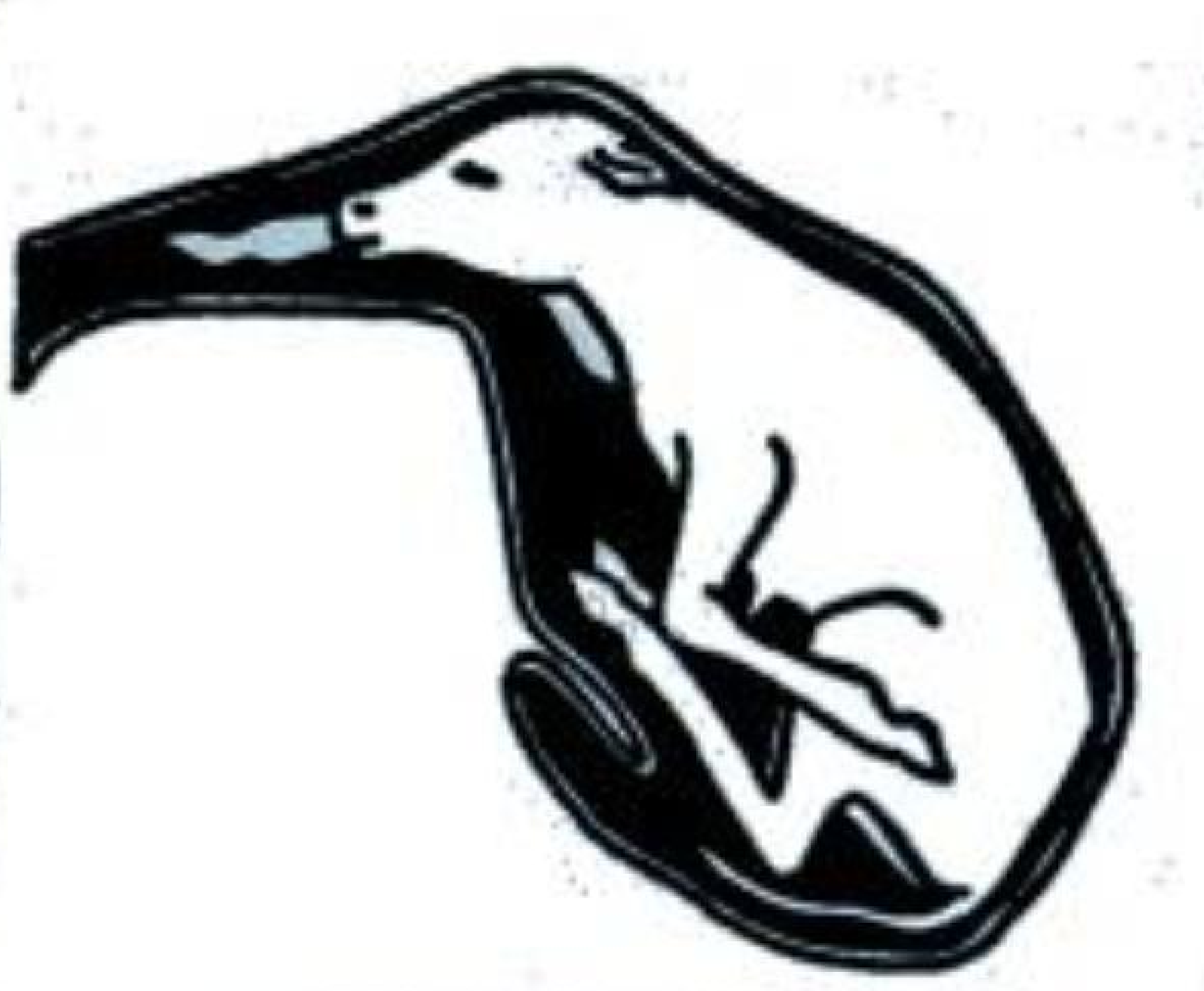
ABNORMAL BIRTH POSITIONS



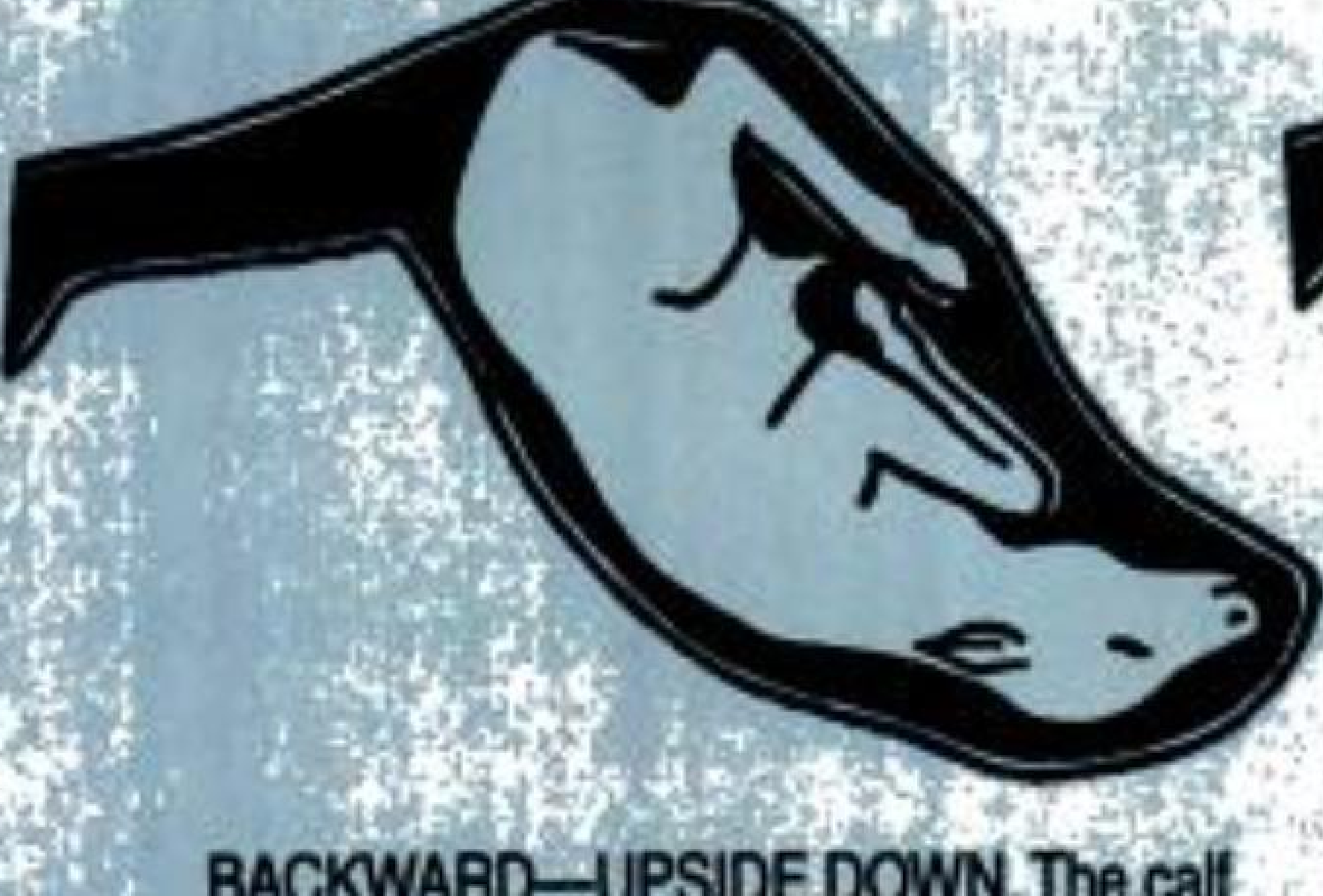
CALF UPSIDE DOWN. A veterinarian will usually turn the calf. Occasionally, such a calf must be delivered backward.



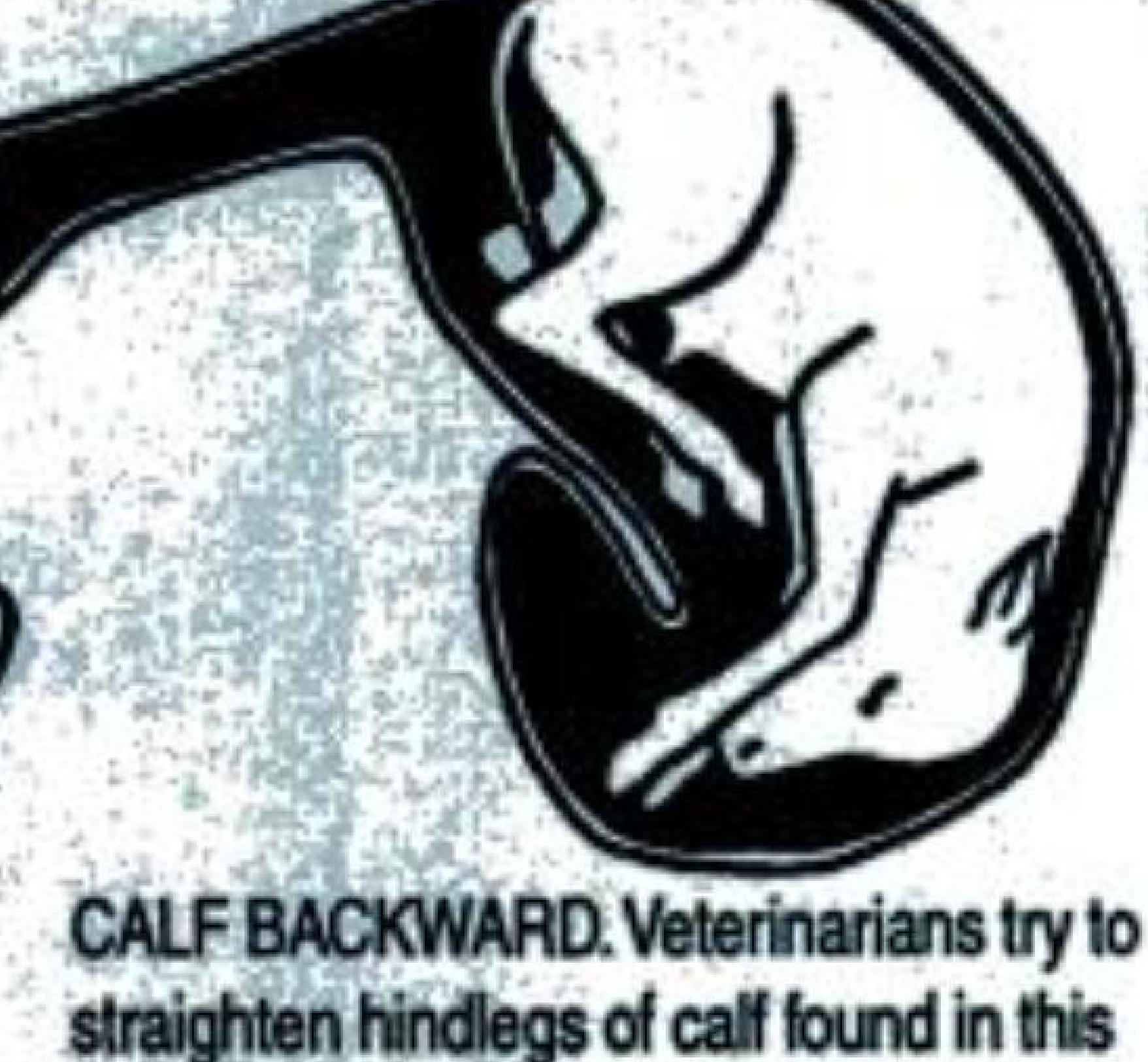
HEAD BENT BACK. If the veterinarian can push the calf back into the cow, he often can bring the head into position.



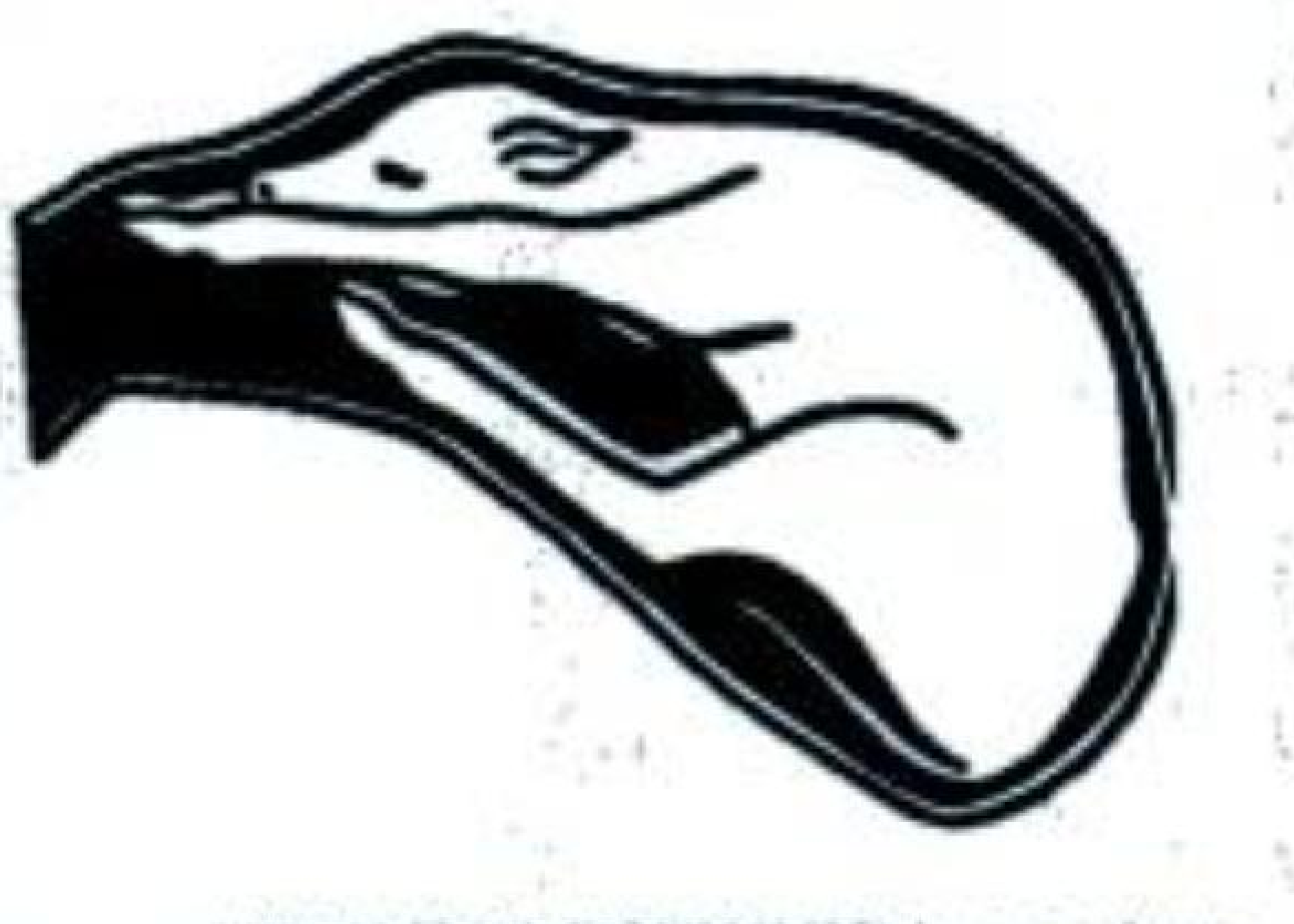
FORELEG RETAINED. In this presentation, the retained leg must be brought forward joint by joint so the calf can be delivered.



BACKWARD—UPSIDE DOWN. The calf must be turned in the uterus until it assumes the normal position for delivery.



CALF BACKWARD. Veterinarians try to straighten hindlegs of calf found in this position, then deliver calf backward.



HINDLEGS FORWARD is a serious abnormal position if delivery is far advanced. Fetus frequently must be dismembered.

If the afterbirth is not expelled within 12 hours, it is considered a **retained placenta.** The placenta usually dies whether or not it is expelled. Retained placentas can result in reduced fertility.

The retained placenta will usually be shed within a few days. It may be necessary to insert antibiotic boluses or infuse antibiotic solutions into the uterus to prevent infections that may accompany the retained placenta. Some veterinarians recommend administering the antibiotics systemically. The lower portion of the retained placenta may be cut off, but some should be allowed to extend from the cow's vulva. This will help the placenta become detached. Do not tie weights to the afterbirth.

Some veterinarians may prefer to physically remove the afterbirth from its attachments. But removal of the afterbirth before it has been fully released from the caruncles of the uterus may cause more trouble. Usually, when forcefully removed, small fragments of afterbirth are left in the uterus where they decay and result in pus that may remain for weeks.

A recent study demonstrated that attempted or successful manual removal of the afterbirth prolonged the interval from calving to first appearance of a functional corpus luteum by 20 days, increased interval to first service, increased the severity of uterine infection, and prolonged the presence of pathogenic bacteria in the uterus compared with allowing the retained afterbirth to expel spontaneously.

In heifers in which the afterbirth was not removed, the characteristics described above were not different from those in heifers induced to calve but not retaining their afterbirth.

Success in releasing the retained afterbirth by injection of a prostaglandin is limited because it must be administered to the cow within one hour of birth to be effective. Because it is not known which cows will retain their afterbirth at that time, injection of prostaglandin may be given to suspect cows (excessively fat or thin cows, cows with calving difficulty, or those with milk fever or ketosis) that usually retain their afterbirth.

Recovery of the cow. Calving places a tremendous strain upon the well-being of the cow. On top of this, the sudden surge of milk secretion places another great stress on her. These factors make the cow easy prey for many infectious agents during the first days after calving.

It is essential that the cow be in a clean environment both before and immediately after calving. A clean, straw-bedded box stall or a small grassy pasture is ideal. Cows should not be allowed to calve in a box stall that is used continuously and seldom cleaned. A box stall bedded with sawdust is especially dangerous to both calf and dam. Such a site increases the chance that infection will be spread from one cow to the next.

Provided there is no evidence of disease and the cow calved and cleaned normally, she should be returned to the milking herd. Prolonged isolation of a healthy fresh cow is unnecessary.

Following each use, the maternity stall should again be scraped free of manure and bedding, washed with soap and water, and allowed to dry for 24 hours. If there is evidence of disease, the stall also should be sprayed or rinsed with a disinfectant and allowed to dry for at least two or three days. The stall is then ready for the next occupant.

A temporary change in the calving facility is recommended when an infectious disease of the cows or calves is present.

After calving, some bleeding may occur from the caruncles on the inside of the uterus. But the blood supply to these is normally quite limited by this time, causing them to gradually decrease in size.

At the time the afterbirth is expelled, the caruncles may be as much as 2 inches high and 2 inches in diameter. By three weeks after calving, they have decreased to about 1/4 inch high and 1 inch in diameter, dimensions still considerably greater than normal.

A few quarts of fluid, containing blood and bits of tissue (lochia) usually are found in the uterus during the first few days after calving. This fluid generally disappears during the first three weeks after calving. Normally, this is not an infection. However, uterine infections frequently occur, even in normal calvings.

A good indication of the beginning of an infection is the odor of the discharge. The bloody discharge, which is normal during the first two to three weeks after calving, should not have a strong odor. If the discharge shows pus or has a foul odor, the cow should be given prompt attention.

The normal uterine defenses against bacteria are not as effective just after calving. This is one reason why a **clean** calving area is so important. It is also the reason why the average dairy producer is well-advised to call a veterinarian to assist abnormal births.

As pointed out in previous chapters, the cow should be in good physical condition at calving time. Good nutrition and proper care during the dry period are quite helpful in preventing calving complications. The cow alone cannot accomplish her important goal of carrying and delivering a normal, healthy calf. She is dependent upon the care and management given her by the dairy producer.

Prevention of difficult calving. Because about 50 percent of the herd calving difficulties occur at first calvings, efforts to prevent this problem are warranted. Most calving difficulties in heifers can be prevented by carefully selecting sires to which heifers are bred for the first time. Because heifers should enter the milking herd no later than 2 years of age to maximize lifetime performance and reduce their maintenance costs, inseminating growthy and well-developed heifers at younger ages offers the advantage of earlier recovery of their rearing costs. However, special attention **must** be paid to their nutrition program and growth (stature and weight).

Proven sires with known calving ease (less than 9 percent DBH – difficult first births in heifers) should be used as breeding sires to avoid extra large calves in heifers. It is not difficult to find excellent sires with acceptable levels of calving ease: 39 of the top 100 Holstein sires in the USDA Sire Summary (July, 1995) had DBH scores of 8 or less (9.2 percent is breed average for Holstein sires). The Sire Summary (Bull List) is published semi-annually in February and August issues of HOARD'S DAIRYMAN magazine. A DBH of 8 for a sire means that only 8 of every 100 calves born to heifers that he sired will have a calving difficulty score of 4 or 5 (very difficult birth requiring assistance).

Chapter 8
When should cows be bred?

BREEDING COWS AT THE WRONG TIME is one of the main causes of infertility. This statement is unanimously supported by those who work in reproduction.

Infertility caused by breeding at the wrong time is a needless waste! Certainly, there are many causes of infertility that cannot be predicted and consequently, are very difficult to avoid. **But timing of the insemination is one thing that we can control if a good job is done in the area of heat detection.**

Age of heifer. Well-fed heifers normally will show their first heat period (puberty) at 9 to 11 months of age, though they may ovulate even earlier. Poorly fed heifers, however, may not come into heat until they are 20 months or more of age. Puberty appears to occur when heifers achieve about two-thirds of adult size, rather than at a constant age.

Nevertheless, once heifers reach puberty (start coming into heat), age and size have comparatively little effect on the percentage that become pregnant. This is true for heifers bred at 14 to 16 months of age, and for older animals bred for the first time at 2 to 3 years.

After that age, there is a tendency toward poorer reproductive performance. Females not mated before 4 years of age may tend to develop irregular estrous cycles, cystic ovaries and other reproductive disturbances.

There is a popular opinion that breeding heifers while they are too young will retard their ultimate size. **Experiments have shown that the age of breeding has little, if any, effect upon the ultimate body size provided the animals are well fed during pregnancy and during the first lactation.**

Another popular opinion maintains that breeding heifers when they are too young may shorten their life expectancy. Investigations in Scotland, Sweden and Wisconsin have shown this idea to be largely unfounded. There is little or no indication of shorter productive life due to earlier calving. **Actually, heifers calving at about 2 years of age have a higher lifetime production total than if they calve for the first time at 3 years.**

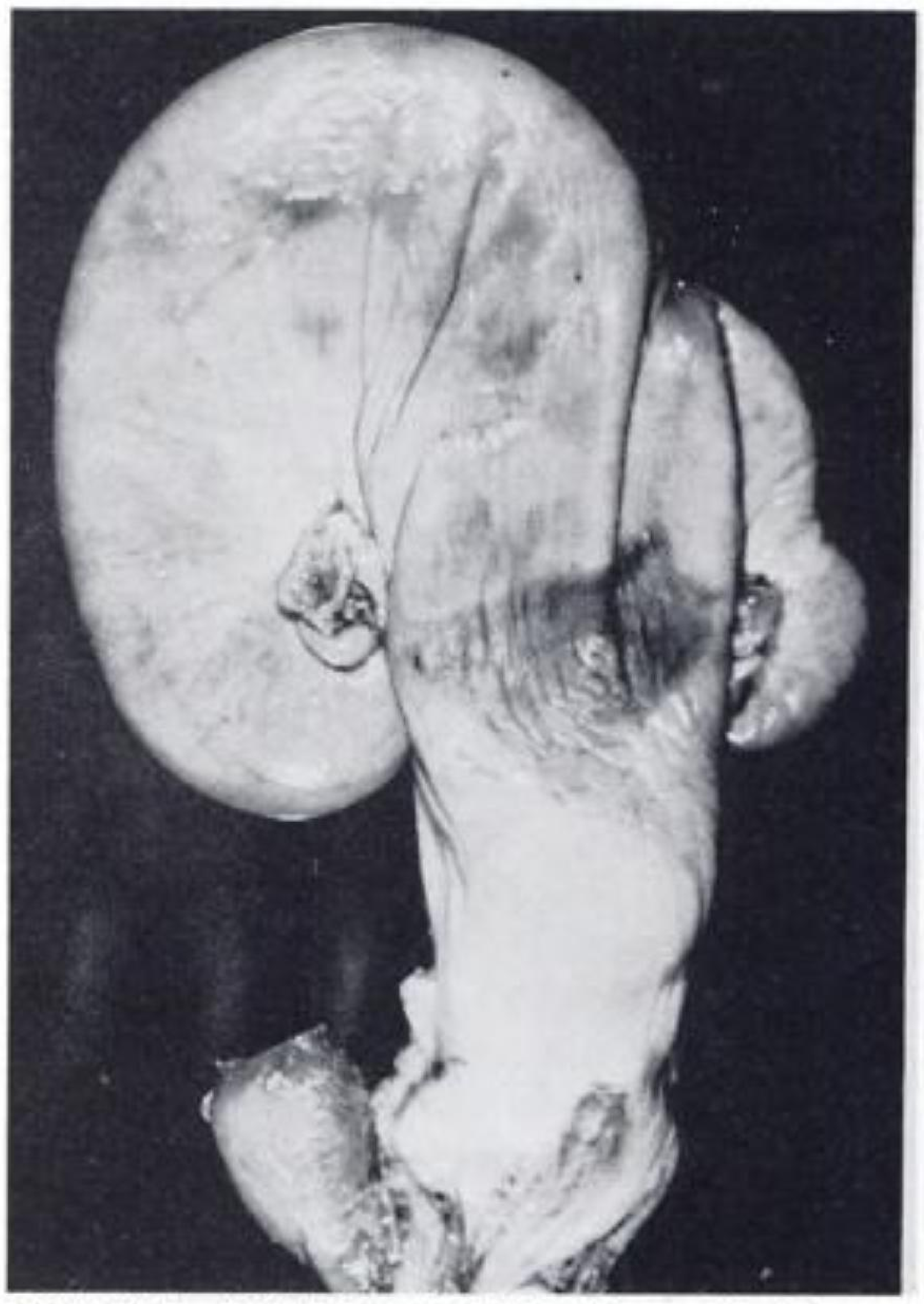
It is true that older heifers yield more milk in their first lactations than do younger heifers. However, after the first lactation, age at first calving has only a small effect on milk yield. Early-calving heifers start paying for their keep sooner and maintain a higher cumulative milk yield all their lives.

Perhaps the most important consideration in determining when to breed heifers is the ability of the heifer to deliver a calf. New York and Tennessee nutrition studies indicated that small heifers may have severe calving difficulties. Such difficulties can cause permanent infertility or even death of the cow. They may also lower the expected milk production in the next lactation. Thus, ease of calving is much more dependent upon size than upon age.

In order to assure safe calving size, the postcalving weight of heifers should be at least 1,200 pounds for Holsteins, 850 pounds for Jerseys, 1,000 pounds for Guernseys, about 950 pounds for Ayrshires and about 1,100 pounds for Brown Swiss.

Therefore, **well-fed** Holstein heifers may be bred at 15 months of age. On the average, the heifers will weigh about 800 to 850 pounds at this time.

Breeding dairy heifers to beef



COW'S UTERUS AFTER CALVING weighs 10 times more than nonpregnant uterus. Horn on right contained a gallon of debris and blood clots.

bulls, in an effort to produce a smaller calf that might result in less calving difficulties, is a questionable procedure. In the first place, if the heifers are grown out well at the time of calving, there is no need for this practice. In the second place, experiments have shown that the size of the dam is the primary factor in determining the birth weight of the calf.

The sire also affects a calf's birth weight. There is almost as much difference in birth weight of offspring between bulls within a breed as there is between bulls of different breeds. This means that certain Holstein sires may be just as effective as some beef bulls in siring small offspring from first-calf Holstein heifers. These "smaller" offspring from Holstein matings do not necessarily remain smaller all their lives. See the discussion in Chapter 7 on using DBH scores of sires to avoid calving difficulty in first-calf heifers.

Data from Michigan herds indicate that first-calf heifers make up about 30 percent of the herd. This means that 30 percent of the heifer calves born are from first-calf heifers.

If 30 percent of the heifer calves born each year are sired by beef bulls, nearly all of the other heifer calves (from the older cows in the herd) must be kept for herd replacements, **eliminating selection of heifers as a tool in herd improvement.** It is highly recommended that heifers be bred A.I. to a good dairy bull.

Heifers should be checked for heat twice daily; preferably, when they are not being fed. **With frequent heat checks, heifers should be inseminated 12 hours after the beginning of standing heat.** When the onset of heat cannot be accurately determined, heifers should be bred soon after standing heat is noticed. Dairy producers who cannot routinely check for heat should consider estrus synchronization and a concentrated A.I. breeding program for selected months during the year.

Recovery after calving. Cows may show their first heat period any time from 2 to 10 weeks after calving. However, just because a cow shows heat soon after calving does not mean that she is ready to breed. The uterus usually requires from 3 to 6 weeks to recover from the previous pregnancy. And fertility is appreciably lower until after this recovery is completed.

When you have a chance, we suggest you follow a cow to the slaughterhouse if she is to be slaughtered during the first month after calving. Ask the men on the kill floor to show you the inside of the uterus.

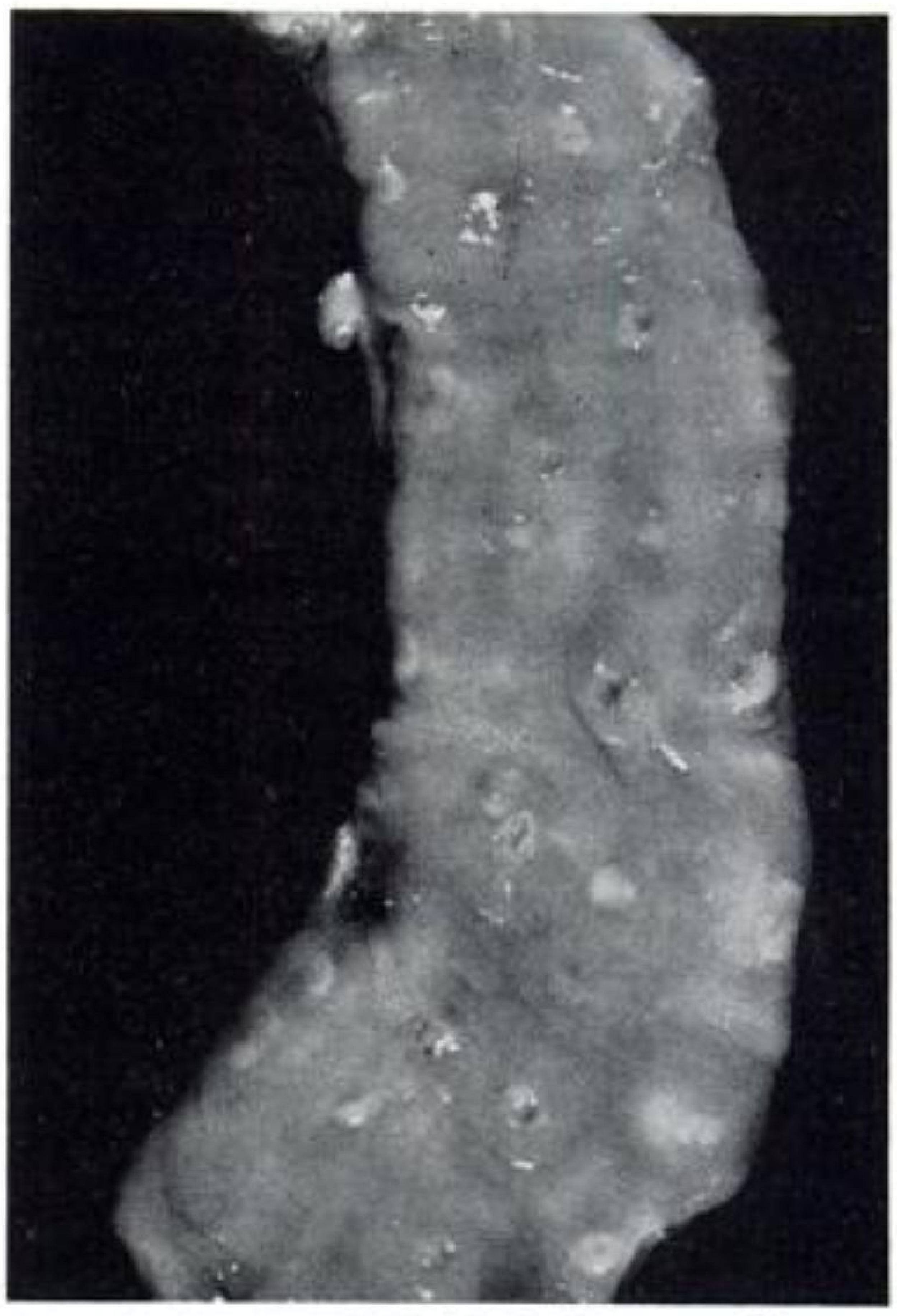
Even if you have never seen the inside of a uterus, you will quickly recognize that it has not yet recovered from the effects of calving. You are likely to see many blood clots and some inflammation of the uterine wall. Having seen it, you will not likely recommend breeding a cow too soon after calving.

By 45 to 60 days after normal calving, the uterus is usually back to normal, and at least 90 percent of the cows should show signs of standing heat by this time. Experiments have shown that fertility of matings made at 45 to 60 days after calving is about 80 percent as high as fertility of matings made at 80 to 90 days after calving. However, not much increase in fertility is gained by delaying breedings beyond 60 to 80 days after calving.

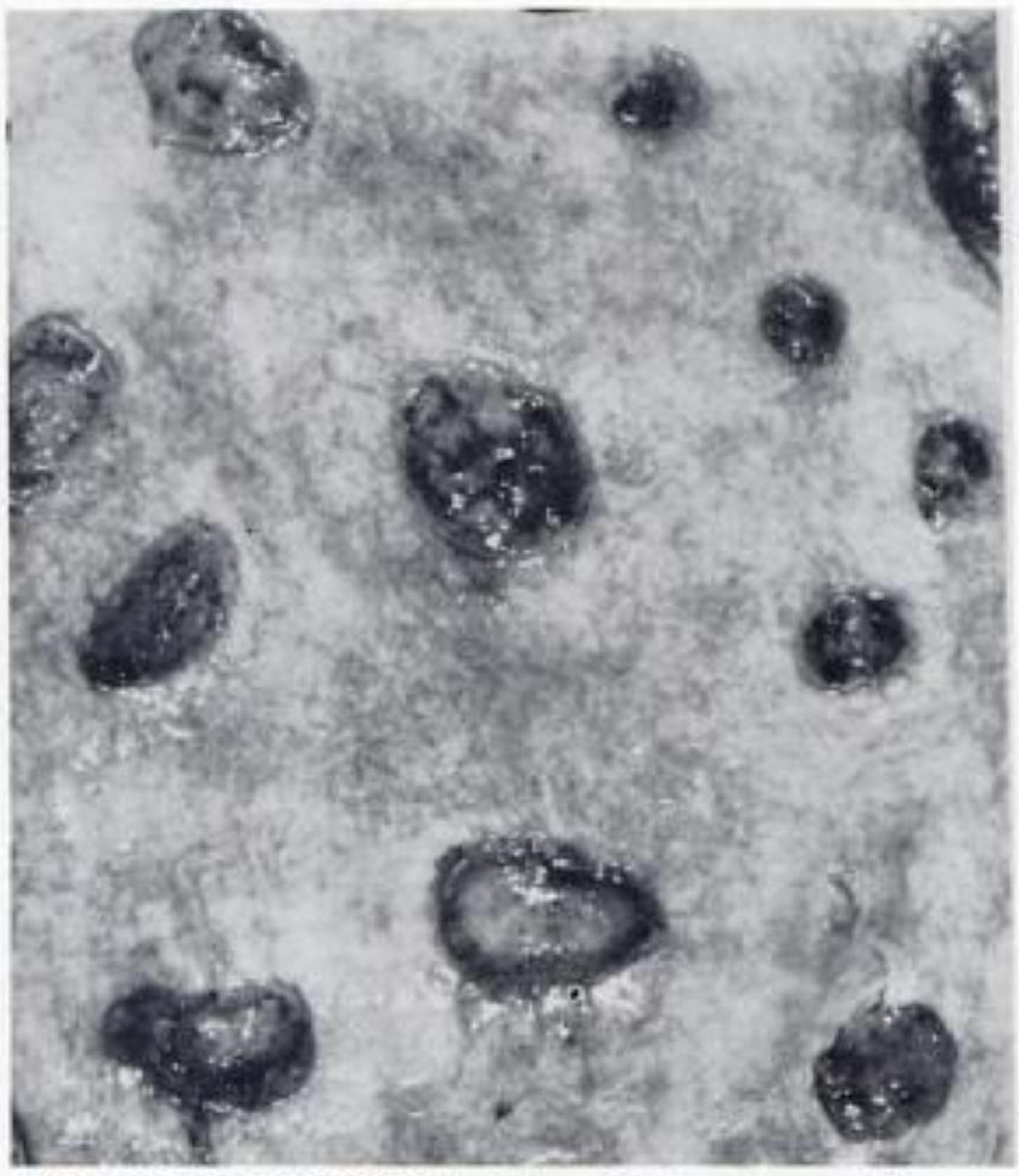
Earlier breeding after calving is one means of shortening the average calving interval of the herd. Cows should not be rebred before 60 days unless palpation of the reproductive tract reveals that the cow is ready for rebreeding. Even 60 days may be insufficient recovery time for cows which had difficulty at calving.

Another way to ask this question is how long should you wait before initiation of breeding after calving? There should be a herd goal of when to start breeding or an established voluntary waiting period (50 to 60 days)—if your veterinarian has examined the cows and declared them OK to breed. With good heat detection, the average days to first breeding should be 70 to 75 days.

If the cow is bred successfully soon after calving, her production for the lactation will be somewhat lower. The first 5 months of pregnancy have no apparent effect upon lactation. Following 5 months, however, the effects of pregnancy become progressively greater.



INSIDE OF A UTERINE HORN normally is pink and smooth. Notice the caruncles, or "buttons."



INSIDE OF A UTERUS after calving shows the damage resulting from the birth of a calf.

Experiments have not shown consistent effects of stage of lactation on reproduction. High-producing cows will breed back on schedule if they are healthy and well fed. In some herds, high-producing cows are less fertile than lower producers. However, in other herds fertility is similar between high and low producers. Much of the differences in reproductive performance between high and low producers may be due to differences in how cows are managed rather than to differences in level of milk production.

Silent heat. Actually, most so-called silent heat periods are simply missed heats due to poor heat detection techniques. A silent heat occurs when the cow ovulates but shows little or no signs of heat. Silent heats are more prevalent within the first 50 days after calving. In many of these cows, silent heats occur prior to the first visible heat.

The heat period involves a series of changes affecting almost every part of the cow. The cow is usually **more excitable,** showing signs of **restlessness. A clear mucous discharge from the vagina and reddening of the vulva are typical.** Cows in heat usually **mount other cows.** These are all important signs of heat.

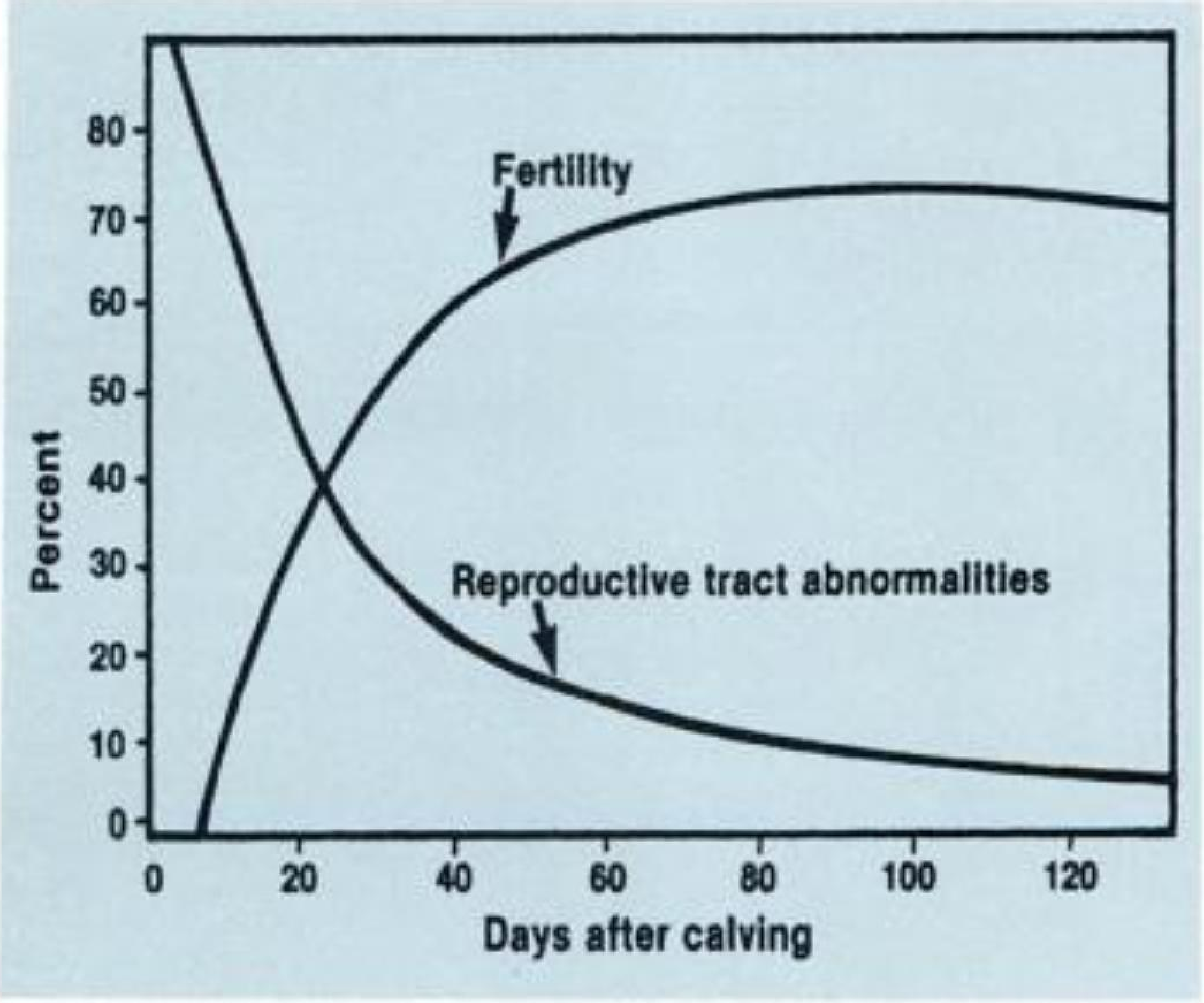
However, **standing to be mounted** by another cow is the best single characteristic of the heat period. You cannot watch cows for standing heat while they are stanchioned. They must be turned outside.

Fortunately, turning cows out-of-doors for a short period each day may be beneficial to cows in other ways, too. It appears to improve appetite and help minimize udder congestion at calving.

Heat detection is one of the most important, yet most abused areas, of reproductive management. Missed heats are not the only heat detection problem. Studies from New York, Virginia and California have revealed that about 15 percent of all cows that were bred were misidentified as being in heat and had no chance to conceive.

A good heat detection program should give cows a place to exhibit heat and should increase the chances that someone will be on hand to observe that behavior. The following are management suggestions for an effective heat detection program.

- Appoint one person to be responsible for heat detection, and allow time to do the job properly.
- Observe cows at least twice daily; 50 percent of all cows are in heat less than 8 hours—therefore, **a third observation period is strongly recommended.**
- Spend at least 15 minutes during each observation period—mounts only last 2 to 3 seconds, and cows must be given the chance to interact.
- Avoid combining heat detection with other chores.
- Record all heats whether the cow is to be bred or not. Heat detection will improve if future heats can be anticipated.
- Provide an area where cows are free to interact and have good footing and few obstacles. Turn cows out on a dry, dirt surface for best results.
- When cows are lying down, check for mucus, rough tailheads, abnormal discharges or the bloody discharge that indicates a previous heat (2 to 3 days prior). Then stir cows up to increase interaction.
- Use heat detection aids wise-



REPRODUCTIVE TRACT ABNORMALITIES decrease with time after calving, while the expected fertility increases as tract returns to normal.

ly. Rump-mounted detection devices, prostaglandins, paint stick over the tailhead, hormone-treated steers, cows or heifers should all be used to supplement—not replace—visual observation.

• Pregnancy status should be a key criteria for grouping cows. Keep open cows together to stimulate more heat activity.

Fertility best toward end of standing heat. If inseminations are not made at the correct time in relation to the time of ovulation, then fertility is reduced. Ovulation occurs about 25 to 30 hours after the **onset** of standing heat. But under most conditions, we seldom know the exact time that standing heat begins. Therefore, when a cow is first seen in standing heat, she usually has already been in heat for several hours. For example, if cows are observed at exactly 6 a.m. and 6 p.m. every day, a cow could have been in heat for many hours before she was first observed to stand. Or she could be just beginning heat. So, on the average, a cow observed in heat under these conditions would have been in heat about 5 to 6 hours when she was first observed standing.

Sperm have to spend some time in the cow's reproductive tract before they develop the capacity to fertilize the egg. Therefore, inseminations should be made several hours before ovulation. **To achieve highest fertility, a cow first observed in heat before noon should be bred late in the afternoon that same day. Similarly, a cow first observed in heat in the afternoon should be bred the following morning.** This a.m.-p.m. system is easy to follow and under most conditions should result in good conception rates.

However, the a.m.-p.m. system works best with intense heat detection programs. If cows are observed only twice a day, it is impossible to predict when heat onset occurred, thus timing of insemination is guesswork at best. The figure below gives the biological events during heat that determine the best time to inseminate.

Based on life span of the ova and sperm, transport time of sperm to the site of fertilization and now accurately knowing that on average, cows ovulate 27.6 hours after the onset of standing heat, we recommend that insemination should occur 6 to 18 hours after the start of standing heat.

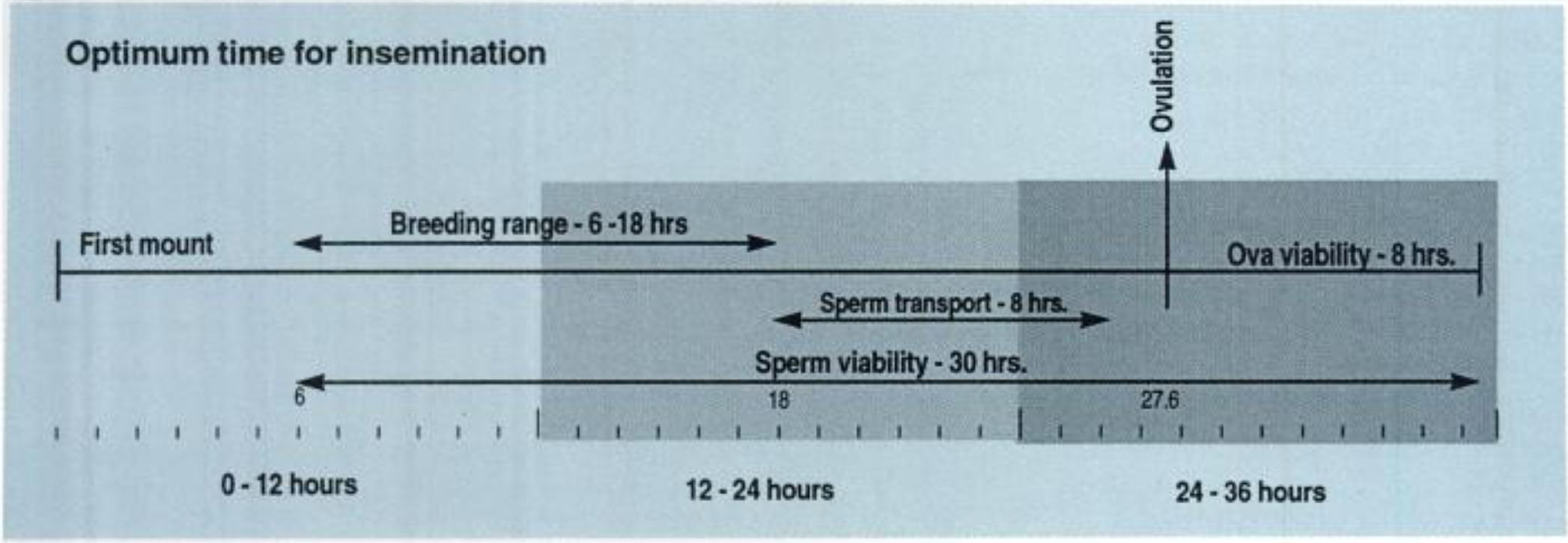
Some cows may deviate slightly from the herd average. For example, a cow may ovulate a few hours earlier or later than normal. But it is impossible, even for experienced veterinarians, to pinpoint the exact time of ovulation, except with ultrasound scanning of the ovaries, which is not practical.

If a cow has been bred several times without success, it may be advantageous to breed her slightly earlier or later than normal at the next heat. Or better yet, give the cow two inseminations—one slightly earlier than normal and the second about 12 hours later. This should assure that viable sperm are present in the cow's reproductive tract at the time when ovulation occurs.

Also, the discharge of blood following estrus provides a good clue as to whether the cows were bred at the proper time during estrus. Postestrus bleeding usually appears (if observed at all) about 48 to 54 hours after the onset of standing heat. The appearance of blood should follow breeding by about 30 hours.

If blood is observed consistently 40 to 48 hours after service, it indicates the cows were bred too soon after coming into estrus. If it is observed at or soon after breeding, then the cows were bred too late.

The same cow variation exists for other phases of reproduction, including the length of the estrous cycle and length of gestation, another reason why reproduction records on individual cows are so important.



Chapter 9

Can we feed for fertility?

DURING THE LAST 25 YEARS, we have made tremendous progress in understanding the nutritional requirements of all classes of livestock. Today, farm animals — especially dairy cattle, swine and poultry—receive diets that are closer to meeting their real nutritional needs than do most humans. This has come about not only because of knowledge gained about nutrients and nutrient requirements, but also because we have developed rapid techniques for analyzing feedstuffs and balancing complex rations.

Even though we have made tremendous progress in developing well-balanced rations for dairy cattle, we still have not learned how to meet all of a cow's nutritional needs when milk production exceeds about 100 pounds per day. And in many herds, nearly every cow will peak at or above 100 pounds of milk per day. This usually occurs just before the time that cows should be rebred after calving. So it becomes a real challenge to meet a cow's nutritional needs for both lactation and reproduction. One of the major components of high reproductive efficiency is obtaining a successful pregnancy in the high-producing dairy cow by 100 days postpartum.

The nutrients required for reproduction are those required for many other body processes. To the best of our knowledge, there is no single nutrient required for reproduction that is not also required for growth or for milk secretion.

Because infertility may result from one of many causes or a combination of many causes (both dietary and other), scientists have had difficulty in determining the nutritional requirements for reproduction.

Energy. One of the most common forms of nutritional infertility results from an insufficient supply of energy or negative energy balance. Many experiments have shown that underfeeding heifers seriously delays sexual maturity. Once the slightly underfed heifer reaches puberty, her fertility is apparently normal once fed a balanced diet.

Numerous reports have shown that stunted heifers or those in poor condition are likely to have infantile ovaries, irregular heat periods and decidedly lower fertility. In severe starvation, the estrous cycle ceases.

Some dairy producers simply

pasture yearling heifers all summer. There is a strong tendency to forget those heifers until it comes time to breed them. Then heifers may look thin and do not come into standing heat. The vast majority of these difficulties can be prevented or cured with an adequate grain ration combined with an effective parasite control program.

Studies have shown that heifers fed adequate roughage with proper supplementation will reach breeding size by 12 to 14 months of age. Holstein heifers gaining a minimum of 1.5 pounds daily from birth to calving can calve at 24 months of age weighing 1,200 pounds or more after calving.

Often we associate rapid growth with fattening, but there is a distinct difference. However, many dairy producers still believe that overfeeding results in infertility. This opinion appears to be based, at least in part, upon experience with beef cattle. Experimental evidence for this idea seems to be lacking.

Some people feel, however, that excessive fat deposits around the ovaries and oviducts of cows can cause infertility. But in our experience in removing reproductive tracts from several hundred animals, we have never seen excessive fat deposits immediately surrounding the ovaries or oviducts.

In a large experiment in New York State, heifers were fed about 40 percent above recommended energy levels and showed no infertility at the time of first breeding. Some of the data, however, indicated that overfeeding may increase infertility at later breedings.

Excessively fat heifers are undesirable but not necessarily from the standpoint of infertility. Studies have shown that fattened dairy heifers produce less milk after calving than heifers grown normally. In fact, excessive fattening of heifers is almost as harmful to subsequent milk production as underfeeding.

Get high producers bred. Meeting the energy requirements of a high-producing cow during peak lactation is much more difficult than meeting the needs of a growing heifer. Rations designed to promote maximum milk yield during a lactation should give the best reproductive performance.

Cows attain maximum dry matter intake at approximately 8 to 10 weeks into the lactation. Since peak production occurs earlier, at approximately 4 to 6 weeks, dairy cows are usually in a negative energy balance for 6 to 8 weeks. During this period, the cow will usually lose weight accumulated during the last lactation and maintained during the dry period.

In high-producing cows, first breeding after calving will often occur while the cow is still in a negative energy balance. This may result in a slightly lower conception rate than would be the case if the cow were gaining weight. The second service will nearly always occur during a period when the energy balance is positive. Proper energy balance is important to the resumption of ovarian cyclicity and the ability to obtain acceptable conception rates of 50 percent or greater.

High-energy rations formulated to provide adequate roughage value may benefit fertility. In addition, rations containing buffering compounds may reduce "off-feed" problems and consequently result in more feed intake during peak lactation.

Many dairy producers accept that high-producing cows are more difficult to get pregnant. In one survey of high-producing herds, days open didn't suffer compared to average herds, but there were more breedings per conception.

The metabolic demand of high production can affect how soon a cow will ovulate. Cows experience negative energy balance during early lactation because they can't consume enough energy to keep up with production. So a prolonged negative energy balance can mean delayed first ovulation and also lowered conception rates.

If a cow is carrying adequate body condition when she calves, she has more body reserves to draw upon. This lessens the severity and duration of the negative energy balance, and will help her reproductive performance. However, you don't want cows too fat when they are dry, or they will experience a number of metabolic problems at calving.

Ideally, body condition scores, based on the 1 to 5 scale developed at Virginia Tech, are as follows: drying off and calving, 3.5 to 4.0; prebreeding exam, 2.0 to 2.5; pregnancy exam, 3.0; late lactation, 3.0 to 3.5.

Also, body condition score should not drop more than 1.0 unit between calving and breeding. Reproductive performance often will be impaired if cows lose more than 1.0 body score unit the first 5 weeks after calving.

It also is important that body condition is not lost during the dry period. During late lactation, the desired body condition should be obtained and maintained until calving. Maximizing dry matter intake as soon after calving as possible is important in minimizing the negative effects of energy balance and body condition lost.

The time between calving and first ovulation will be about 15 days longer, and first service conception will average about 17 percent, compared to 55 percent for cows with minor condition loss.

The combined delayed ovulation and reduced fertility lengthen days open by 42 days, about two heat periods. These findings are based on a Cornell study.

The body condition of dairy replacement heifers is also important. A heifer that grows too slowly will join the milking herd late. A thin heifer will not have the needed fat reserves for optimum milk production during her first lactation. During the first lactation, energy outflow is more critical because milk yield and growth demand more from a heifer. She quickly finds herself in a negative energy balance.

At 12 months of age, replacement heifers should average a condition score of 3.0. At 24 months of age, heifers in high-producing herds average a condition score of 3.5 to 3.75.

The following illustrations show examples of the body condition scores. As a rule, cows should range from a 2.0 to a 4.0 score, depending on their stage of lactation.

Protein. One of the chief economic advantages of cattle over some other animals is their ability to synthesize protein in the rumen. This fact has complicated efforts to determine protein requirements for reproduction.

Recently many universities have investigated the effects of dietary protein on reproductive efficiency. Levels of protein fed ranged from 12.7 to 23 percent. At least four studies have reported that rations containing more than 18 percent crude protein led to a lower reproductive performance in high-producing cows. Other studies have questioned these findings.

Rumen degradable protein – not crude protein – should be the type of dietary protein used to measure the impact on reproductive performance. High levels of rumen degradable protein has consistently shown a negative relationship with obtaining conception in dairy cattle.

The basis for an adverse effect on reproduction is an increase in ammonia and urea in blood and uterine secretions in cows fed high-protein diets. High protein also alters the amount of phosphorus, magnesium, potassium and zinc in uterine secretions or blood. Overall, it appears that crude protein level in the ration should be high enough to support maximum milk production, but not above that. Protein sources that are not degraded as rapidly in the rumen (bypass protein) may be beneficial in supporting high production without affecting reproduction.

Protein content normally is lower in heifer rations in comparison to lactating cow rations. Therefore, protein is usually adequate in most heifer rations, and not normally considered as a factor affecting fertility in heifers.

There is no firm evidence that nonprotein nitrogen (NPN) such as urea has any adverse effect on reproduction when added to the ration at recommended levels. Milk urea nitrogen (MUN) and blood urea nitrogen (BUN) levels have been used to monitor the effects of rumen degradable protein on nitrogen concentrations in an attempt to adjust rations and reduce negative effects on fertility. Although excessive NPN and rumen degradable protein adversely influence reproduction, they are not cause for concern if fed at or below recommended levels.

Vitamins. Ruminants, such as the cow, are fortunate from a standpoint of their vitamin supply. All of the B vitamins, and vitamins C and K are manufactured in adequate quantities by the cow. Only vitamins A, D and E need be considered here. All three of these fat soluble vitamins can be provided through supplements or by using certain feeds that contain adequate levels of each of them.

Vitamin A deficiency in cattle results in blindness (especially night blindness), edema, lower milk production and reproductive disturbances. Vitamin A deficient animals are likely to produce dead or weak calves. Some abortions may occur late in pregnancy, and retained placenta is common.

The live calves born are usually weak, and their mortality rate is high. Eye abnormalities are common in these calves. These deficiency symptoms occur frequently on the range during and following a dry season.

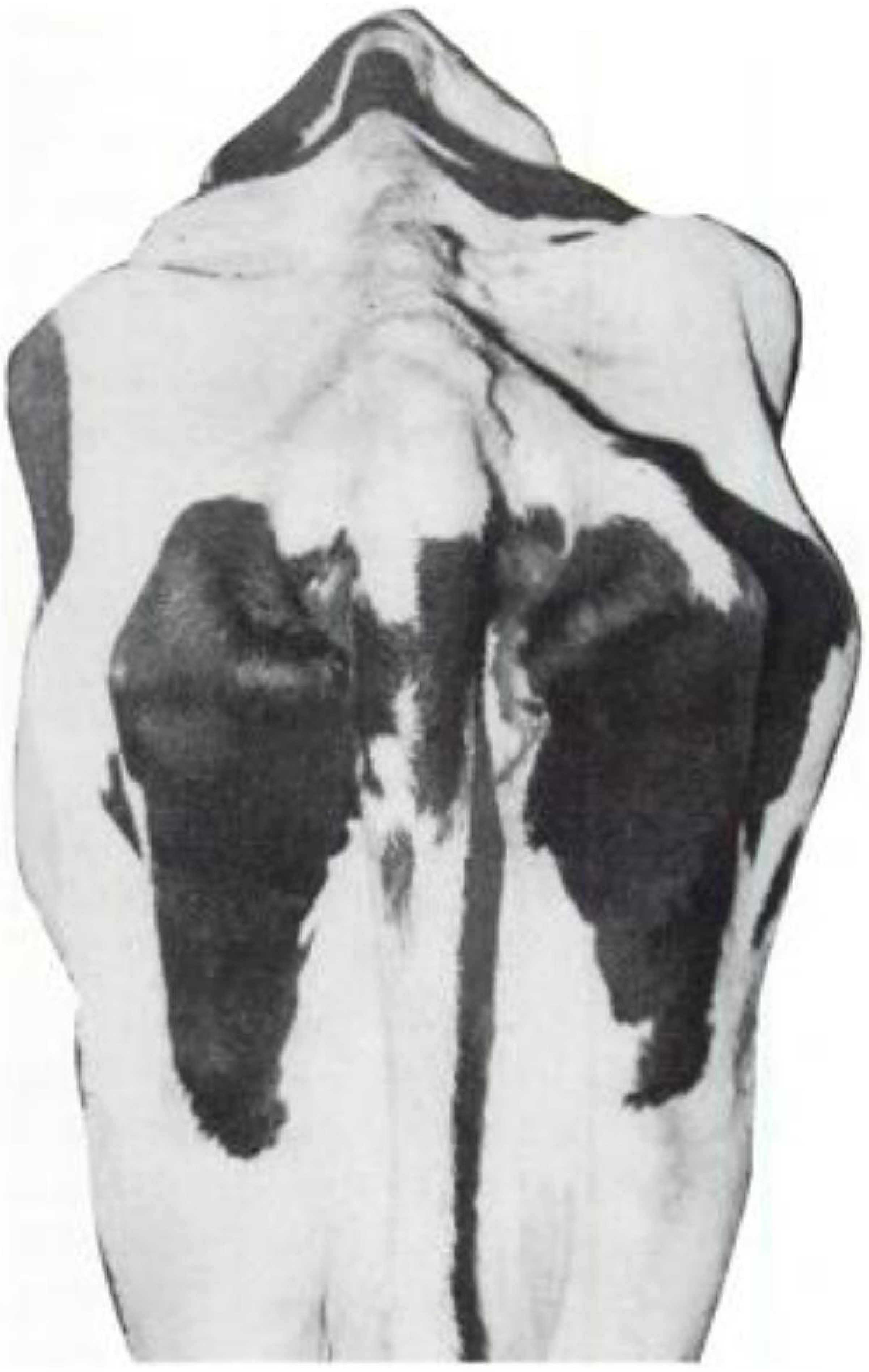
Vitamin A deficiency is easily avoided under most dairying conditions. Good quality alfalfa hay or green chop should provide an adequate amount, though all silages, including alfalfa, are low in carotene, the vitamin A precursor.

Some recent work in Europe suggests that carotene, the plant precursor for vitamin A, is also required for normal reproduction. Cows fed rations devoid of carotene but with adequate levels of vitamin A had irregular estrous cycles, more silent heats and a higher rate of cystic ovaries.

The need for *vitamin D* for reproduction has been demonstrated. The health of vitamin D deficient animals declines, and they do not show heat periods. Calves from cows on rations deficient in vitamin D frequently are born with rickets, which is characterized by faulty bone development.

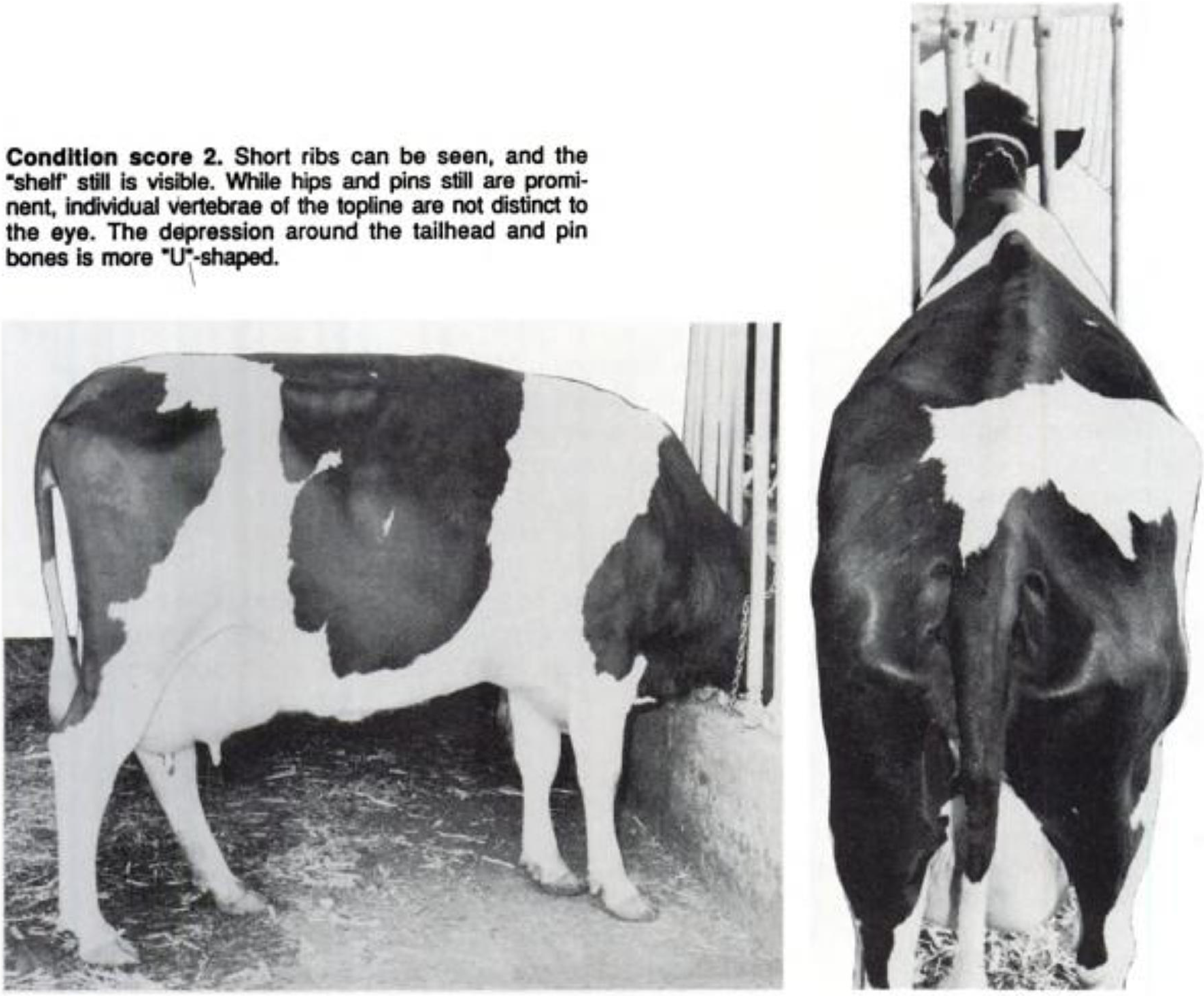
This deficiency is easily avoided by allowing cows periodic exposure to sunlight and by

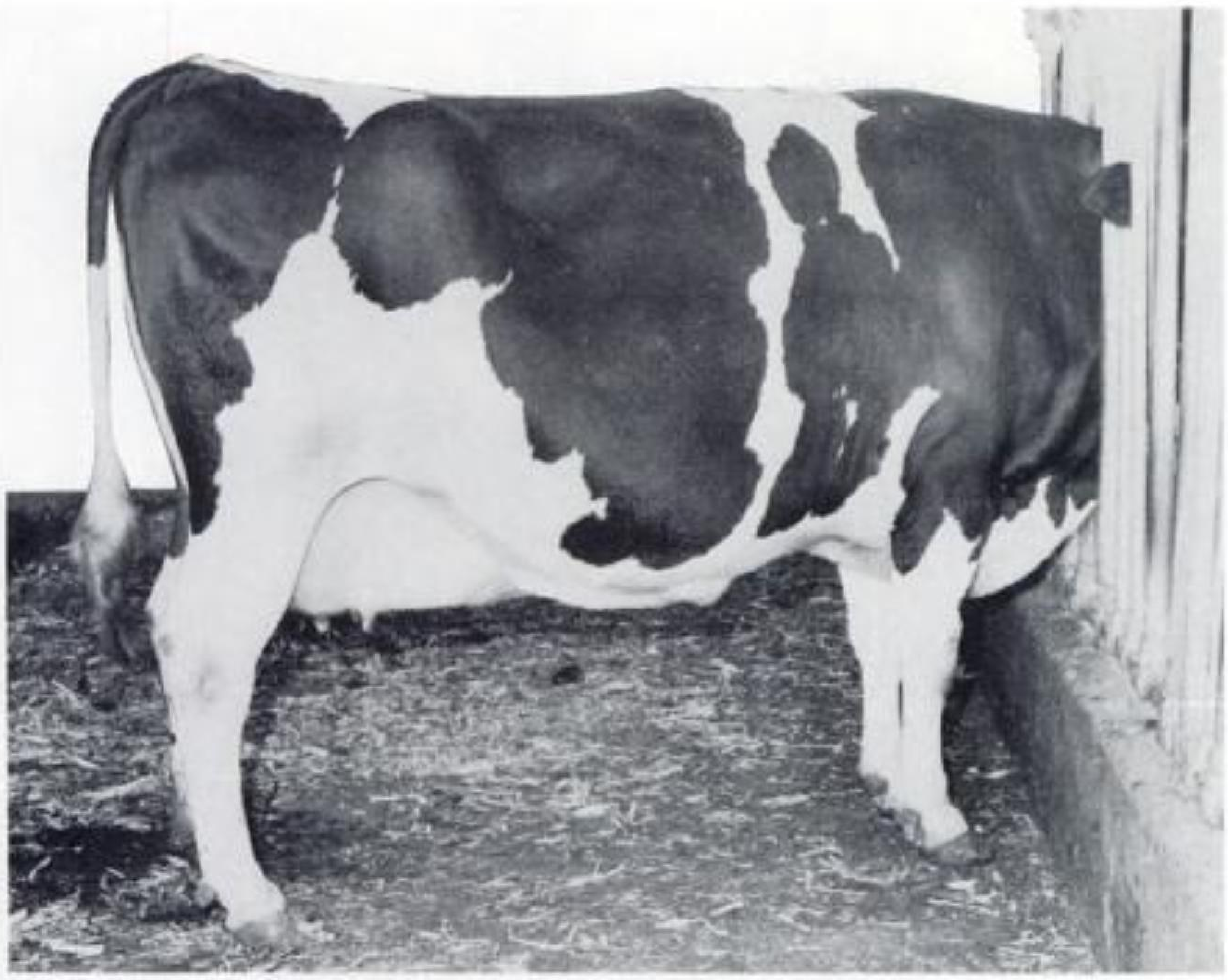
Body condition scoring

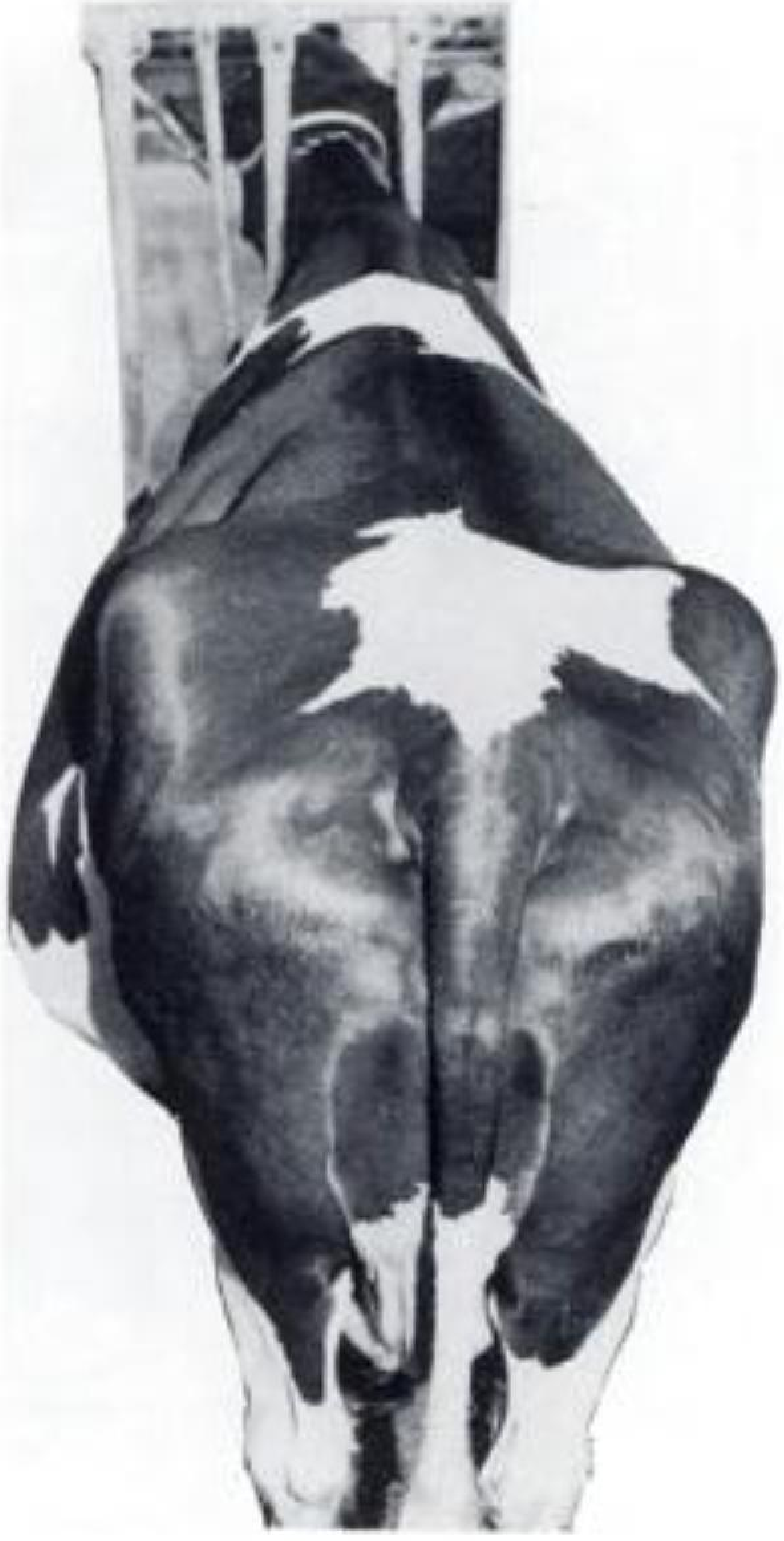


Condition score 1. Ends of short ribs are prominent, and give a distinctly shelf-like appearance. Hips and pin bones are sharp; severe depressions show between hips and pins, and between hooks. A deep, "V"- shaped cavity is below the tailhead and between the pin bones.

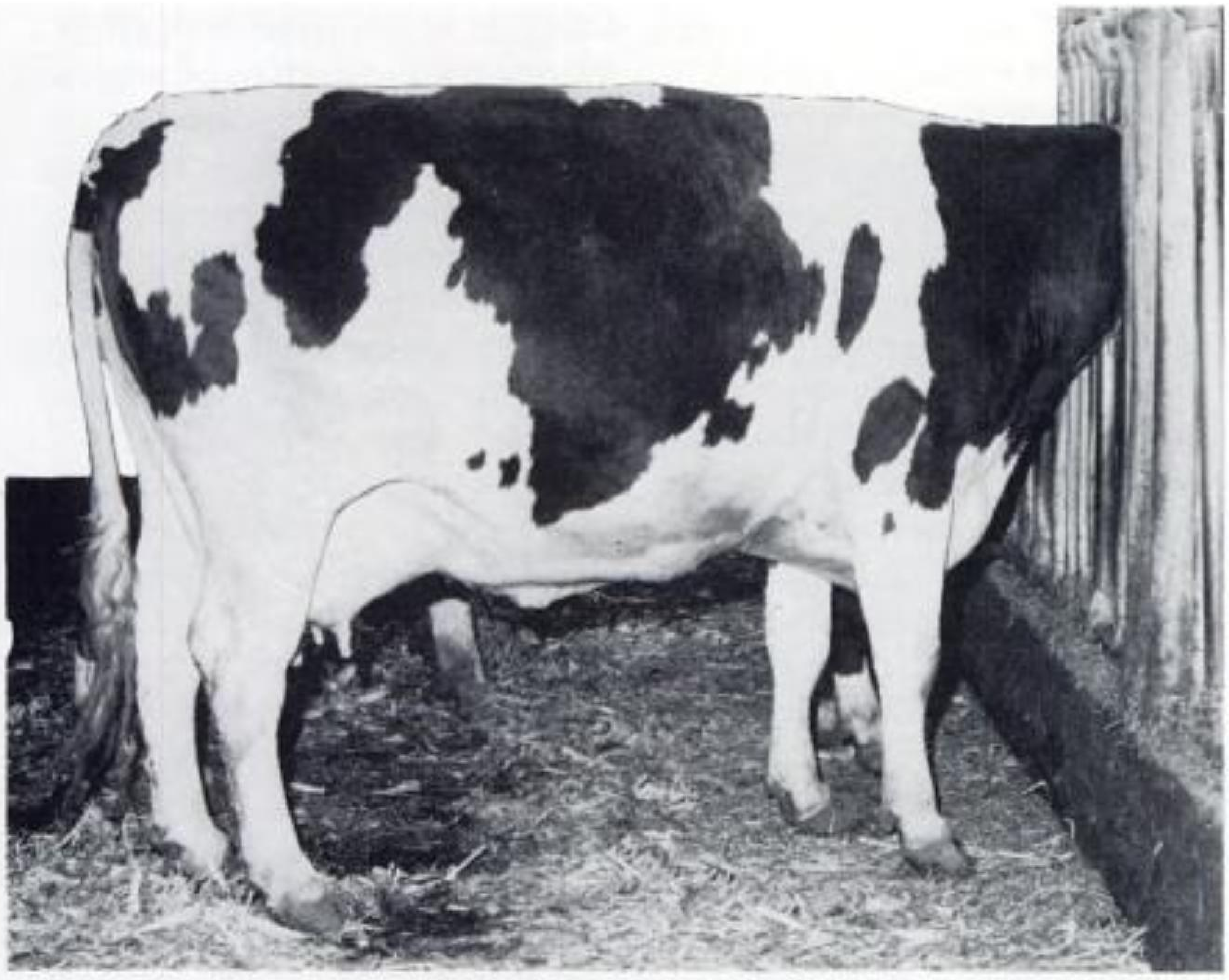
Condition score 2. Short ribs can be seen, and the "shelf" still is visible. While hips and pins still are prominent, individual vertebrae of the topline are not distinct to the eye. The depression around the tailhead and pin bones is more "U"-shaped.

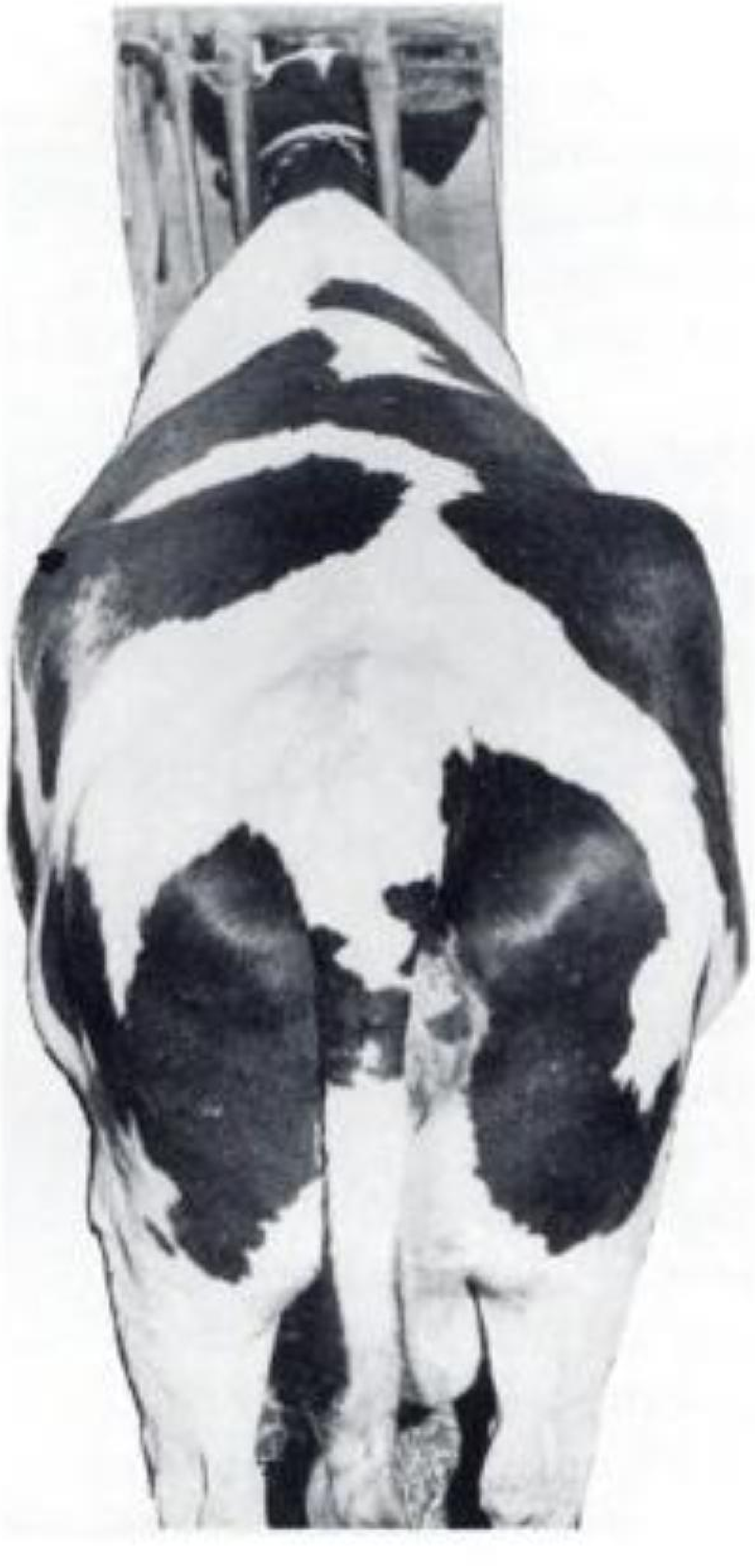






Condition score 3. The short ribs appear smooth, with no shelf effect. The backbone is a rounded ridge; individual vertebrae are not visible. Hip and pin bones are rounded and smooth; the area between pin bones and tailhead has smoothed out.





Condition score 4. Short ribs are smooth and rounded, no shelf effect. The chine region is rounded and smooth; loin and rump appear flat. Hips are rounded and flat in-between. There is a rounded appearance over the tail-head and pin bone area, with evidence of fat deposit.

Occasionally, a feed constituent can serve as a "poison" to reproduction. For example, under certain growing conditions, some of the subterranean clovers may contain abnormally high quantities of estrogen-like chemicals (estrogen is the female sex hormone).

When fed to cows, these feeds may easily upset the estrous cycle or even pregnancy. However, this cause of infertility rarely occurs in the United States.

Excessive fluorine in the ration has been reported to cause lowered birth weights of calves and to delay the first heat after calving. Fortunately, such poisons occur only rarely.

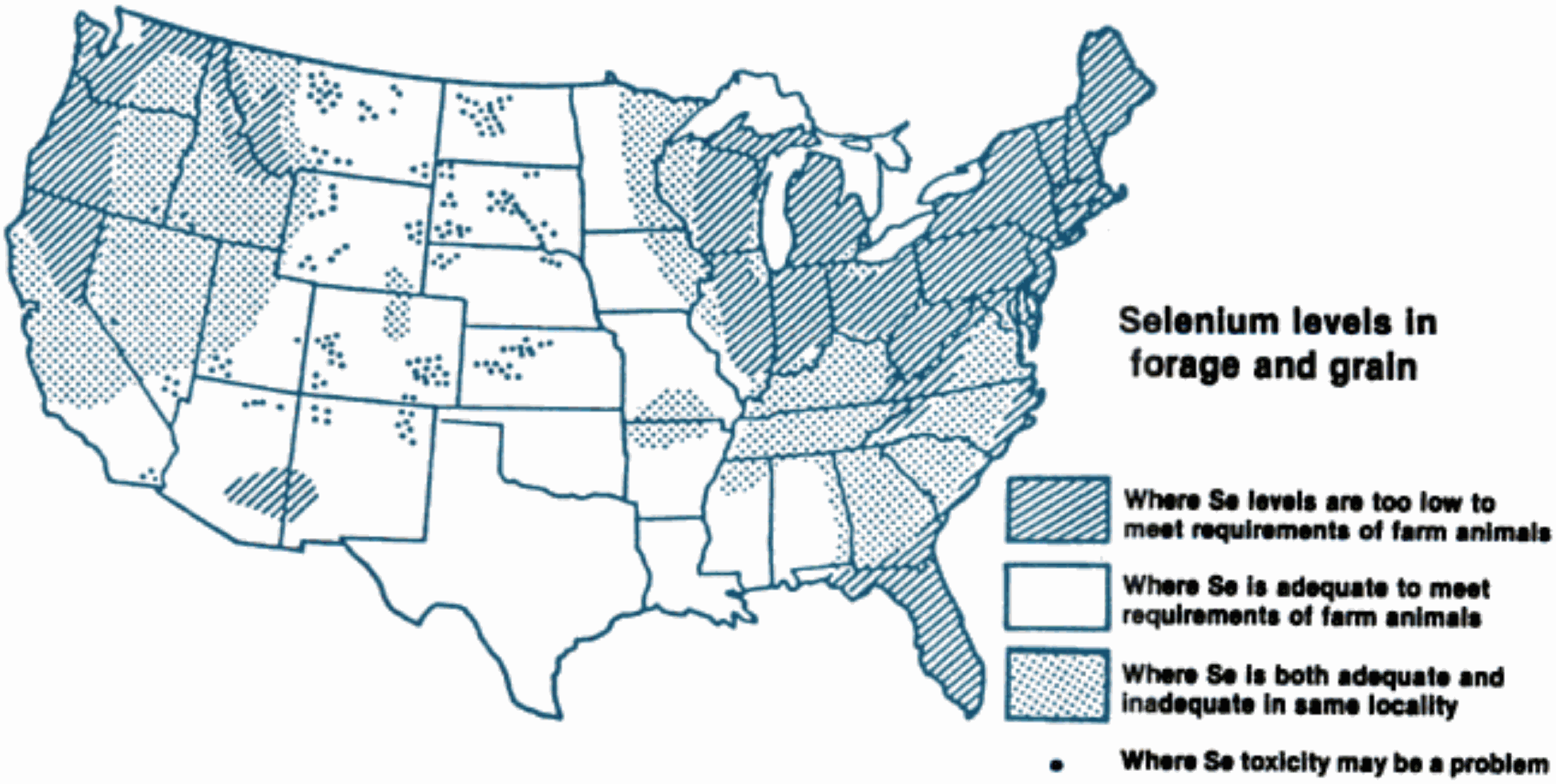
Remember, there are no nutrients specifically required for reproduction. Instead, reproduction requires most of the same nutrients that are required for other body processes.

For most practical circumstances, we recommend feeding cattle for optimum growth and milk production.

The protein and energy requirements for reproduction (even for pregnancy) are small compared to the requirements for growth or for milk secretion.

A period not to overlook in feeding is the dry period. Care should be taken to avoid getting cows too fat when they are dry because this can cause problems at calving. Cows that are too fat or too thin at calving are more likely to have problems delivering the calf, and consequently are more likely to have postpartum problems (retained placentas, uterine infections and cystic ovaries). Also, calcium and phosphorus levels need to be limited somewhat during the dry period. A new concept is to feed anionic (acidic) salts in the dry period to enhance calcium mobilization. Anionic salts are most easily managed in a dry cow TMR. Conversely, anionic salts can decrease feed intake if fed incorrectly, a disaster for dry cows.

Make sure that dry cows receive adequate trace minerals and vitamins. Dry cow rations can provide a good start for the fresh cow and her calf.


Selenium levels in forage and grain

▨ Where Se levels are too low to meet requirements of farm animals
☐ Where Se is adequate to meet requirements of farm animals
░ Where Se is both adequate and inadequate in same locality
● Where Se toxicity may be a problem

Chapter 10

Inherited problems

IT IS WELL KNOWN that certain types of sterility may be inherited in dairy cattle. In other words, certain traits causing sterility are passed on from the parents to the offspring through the genes on the chromosomes in the egg and in the sperm. Some of these hereditary defects actually result in death of the offspring, sometimes before birth.

These hereditary defects are transmitted by recessive lethal genes that may have no measurable effect on the carrier bull or the carrier cow. Since these genes are not visible, the genetic defects or harmful traits may be transmitted in the genetic material along with the desirable traits.

When a carrier bull is mated to a carrier cow, about one-fourth of the offspring would not survive. About one-half of the offspring would be normal in appearance, but would be carriers of the lethal genes. About one-fourth of the offspring would be perfectly normal noncarriers.

Identification and elimination of the carrier animals is the only way to eliminate the lethal genes. Test matings with a known carrier provide the best way to test for and identify suspected carrier animals.

If an animal is born dead because of a hereditary lethal defect, the bull is not entirely at fault. The cow is equally to blame because most lethal genes cause death only when they are passed on from both parents.

Usually, bulls used in A.I. are carefully selected to avoid the undesirable lethal genes. But it is likely that the dairy industry in this country has given too little attention to the harmful genetic defects in cattle. There are over 80 known inherited defects in cattle, and it has been well documented that systematic efforts can be successful in controlling and eliminating some of them.

Years ago, even before A.I. was well established, a genetic defect called gonadal hypoplasia (failure of ovaries and testes to develop normally) affected almost 20 percent of the cattle in a major breed in Sweden. By a careful control program, the condition has been reduced to less than 4 percent.

Dwarfism of Hereford cattle is another example of a more voluntary program to control a genetic defect. This condition reached serious proportions in some beef herds, but staunch efforts by breeders about 40 years ago were effective in greatly reducing the incidence.

Inbreeding lowers fertility. Mating closely related relatives (inbreeding) is widely assumed to cause lowered fertility. Apparently, recessive lethal genes cause most cases of lowered fertility in inbreeding.

An experimental herd of Jerseys at Michigan State University provided an excellent example of what may be expected from inbreeding cattle. This herd was inbred for more than 30 years. No outside breeding stock was introduced during this time.

During the first several years of this experiment, a high proportion of the calves were born with serious abnormalities. Many were dead at birth and some survived for only a short time after birth. Some researchers suspected that the herd might not survive.

However, the recessive lethal genes are "self-limiting" since a dead calf leaves no offspring. With this in mind, the carrier animals in the inbred herd were identified. Some of these were culled. Matings of the rest of the herd were carefully controlled.

After more than 30 years, these inbred Jerseys looked and behaved just about as most Jerseys would be expected to. Their milk production and fertility were essentially normal. Although most of the undesirable traits were culled from the inbred Jersey herd, a few calves were stillborn with lethal abnormalities.

Under many practical circumstances, however, it is not feasible to test whether or not cows carry undesirable recessive genes. For this reason, mating closely related individuals is not recommended for the average herd. In most types of inbreeding (including close linebreeding), the chances of obtaining abnormal calves are considerably greater than when unrelated animals are mated.

Inherited abnormalities. It is not necessary for an inherited characteristic to be lethal to hamper the efficiency of reproduction. Fertility differences between breeds and between cow families within the various breeds provide general evidence that genetic factors are responsible for varying **degrees of fertility.**

Several of these inherited causes of infertility involve anatomical abnormalities. Most of these are the result of improper development of the reproductive tract. In severe cases, the heifer is completely sterile. Less severe abnormalities may permit conception and calving, but only with considerable difficulty.

These cows may require an average of three or four services per conception, even though they appear to be essentially normal.

The most common abnormality characterized by underdevelopment of the female reproductive tract is found in the freemartin. The abnormal reproductive tract of the freemartin is not inherited. However, freemartins occur only among heifers born twins to bulls and the **frequency of twinning seems to be inherited.**

When heifer-bull twins occur in cattle, there is a good chance that the blood vessels of the two placentas will join. Consequently, the male sex hormone (testosterone) from the bull calf enters the blood system of the heifer calf, and in addition, there is usually an exchange of some blood cells between the two calves. This leads to sterility in over 90 percent of heifers born twin to bulls and may also cause an increase in sperm abnormalities and a decrease in semen quality in some of the bulls.

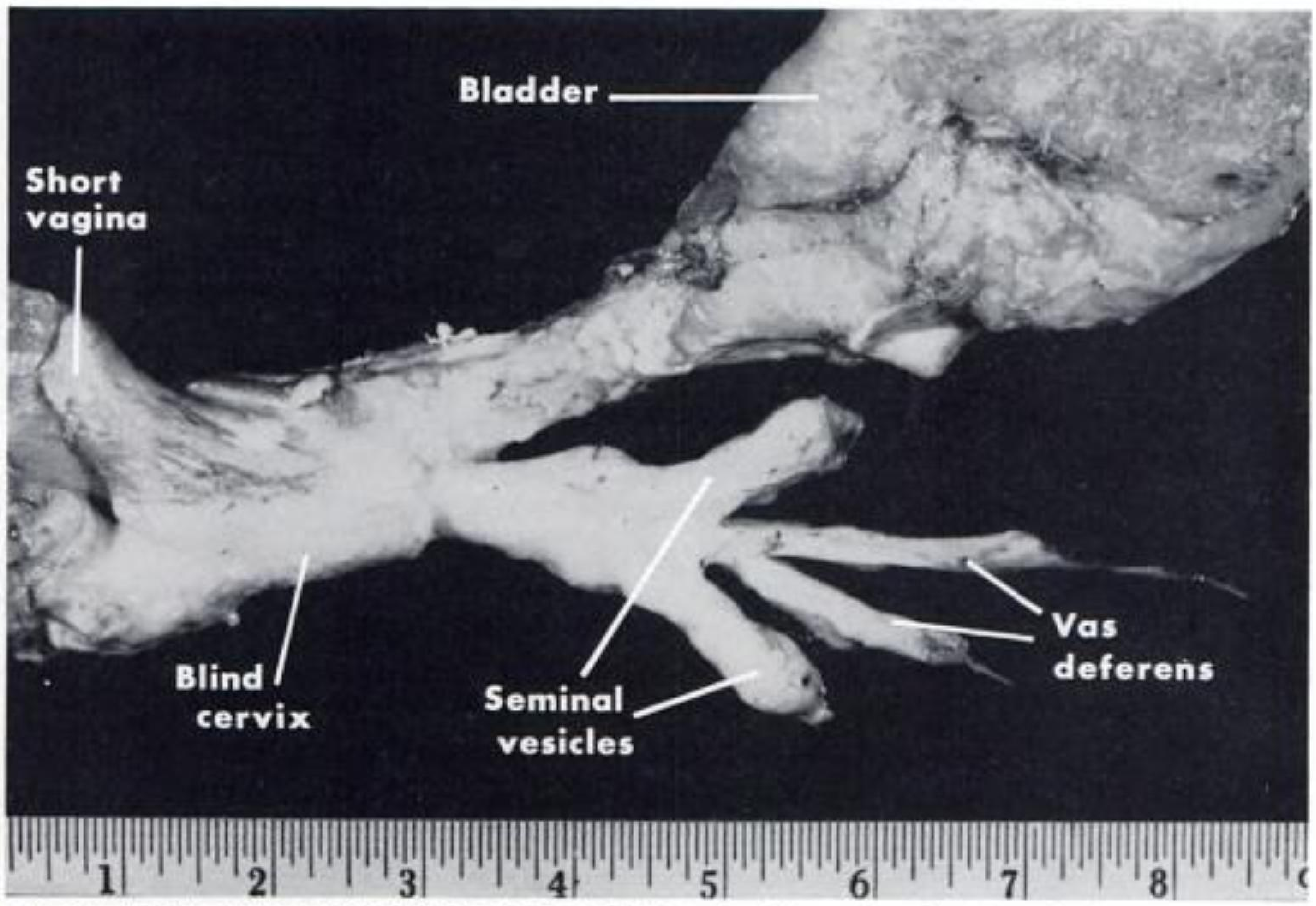
Male organs in female. In the freemartin, the heifer's reproductive tract does not develop normally. In fact, as shown in the photograph at the bottom of this page, the freemartin heifer's reproductive tract may actually develop parts (such as seminal vesicles) that belong to the bull.

On the average, twins occur about once in every 25 births, and triplets once in every 500 births. However, these frequencies are considerably higher in certain cow families.

Twins may be one of two types. The most frequent type occurs when two eggs are ovulated at one heat period. Each may be fertilized separately and develop into twins. These twins are no more related than any two calves born from the mating of the same bull and cow at two different times.

The other type of twins occurs less frequently when an egg splits, to form two eggs, shortly **after fertilization.** Both then may develop and result in twins. In this case, the result is identical twins since the two calves resulted from the union of one egg with one sperm. The freemartin condition never occurs in identical twins because they are the same sex.

Inherited defects and disturbances of the body processes (physiological) probably cause considerable loss in reproductive efficiency. However, such



A FREEMARTIN'S REPRODUCTIVE TRACT. It is badly underdeveloped. The vagina is only 4 inches long, the cervix is blind and the uterus is absent. Growth of some male parts in the freemartin heifer is due to testosterone (male sex hormone) from the bull twin. Note the male sex organs—the seminal vesicles and vas deferens.

Chapter 11
Diseases of reproduction

REPRODUCTIVE DISEASES commonly cause serious economic losses in dairy herds. Disease may strike suddenly, as in abortion storms, or may be more difficult to notice as the cause of increased days open or breedings per conception. As discussed in Chapter 1, increased days open cost the dairy producer $2.35 or more for every day beyond 100 days. Many times this economic loss due to days open is not recognized; the economic losses due to reproductive diseases usually are easier to identify because of the finding of aborted calves and uterine infections. Reproductive inefficiency caused by infectious disease must be considered after eliminating problems with cyclicity, heat detection, A.I. techniques, semen handling and nutrition.

The diseases that affect reproduction in dairy cows can be classified into four main categories:

1. Intrauterine infections which are associated with bacterial organisms. Corynebacterium species and various anaerobes are the major bacteria that cause endometritis (infection of the uterine lining) or the less common metritis (infection of the uterine muscle wall).

2. Venereal diseases which specifically and selectively attack the reproductive tract of the cow and which are spread by natural or artificial breeding. Campylobacteriosis (vibriosis), trichomoniasis and ureaplasmosis are examples of these diseases. They are spread from infected animals to clean animals during breeding.

3. Infectious diseases that attack other organs of the cow's body and also affect the reproductive system. Leptospirosis, Infectious Bovine Rhinotracheitis (IBR), Bovine Viral Diarrhea (BVD) and Brucellosis are examples. These diseases are spread by several routes.

4. Other conditions affect reproduction by lowering the overall health status of the animal. Pneumonia and hardware disease are examples of individual animal conditions, while selenium deficiency and other nutritional disorders typify herd problems.

Uterine infections usually prevent conception but are not always accompanied by outward signs such as an abnormal discharge or abortion. Many dairy producers fail to recognize their importance in causing reduced reproductive performance.

Aside from abortions, the venereal diseases present subtle symptoms that usually require laboratory tests to aid a veterinarian's diagnosis. Often these diseases are undetected until the cow aborts. By this time it already may be too late, and you must move fast to salvage what you can.

The last two categories are easier to detect since they may also cause a sharp drop in milk production, poor appetite, rough hair coat or other externally visible changes.

Endometritis and metritis. Sometimes the infection in the uterus is severe enough to cause the cow to demonstrate toxic signs. These may include loss in production, poor appetite, increased temperature and a foul smell about the hindquarters. However, most cows do not become sick or toxic from a uterine infection (endometritis), making the problem difficult to detect. Cows may only show an off-colored discharge with some flakes of pus during heat. It takes close observation to detect pus in the mucus and treat this probable repeat breeder. An early postpartum reproductive exam by a competent veterinarian will identify those cows with undetected uterine infections in time to allow for treatment and uterine healing before first breeding. Sometimes, intrauterine infection spreads to the muscular wall of the uterus (metritis). This condition frequently causes the cow to demonstrate toxic signs which may warrant immediate veterinary care.

Most postpartum uterine infections begin with either poor hygiene at the time of calving or retained placenta. The resulting endometritis may involve many types of bacteria. In the early postpartum period, veterinarians may recommend intrauterine therapy with antibiotics. However, **milk residues must be considered.**

There are many methods to treat endometritis after postpartum cyclicity resumes. Prostaglandin compounds are commonly used to increase the number of prebreeding cycles, which effectively reduces infections. Any intrauterine therapy should be under the supervision of a veterinarian.

Many uterine infections can be prevented with use of sanitary practices at calving, during uterine infusions and at breeding times. The surest form of treatment for uterine infections is prevention.

Venereal diseases. Presently, Campylobacteriosis (vibriosis) is a serious cause of infertility only in certain locales in the United States. Since it is transmitted mainly by natural mating, it is much more prevalent in beef herds than in dairy herds. But many dairy producers continue to keep and use bulls, thereby increasing the chances of introducing vibrio into their herds.

Repeat breeding problems or abortions between the fourth and seventh months of pregnancy are the first indications of vibrio infection. Most infected cows in the herd require several services before they settle. Heat periods are irregular and many cows will have uterine discharges.

For positive diagnosis, a veterinarian should culture the vaginal mucus from a cow, fluids from a freshly aborted fetus or mucus from the prepuce of the bull.

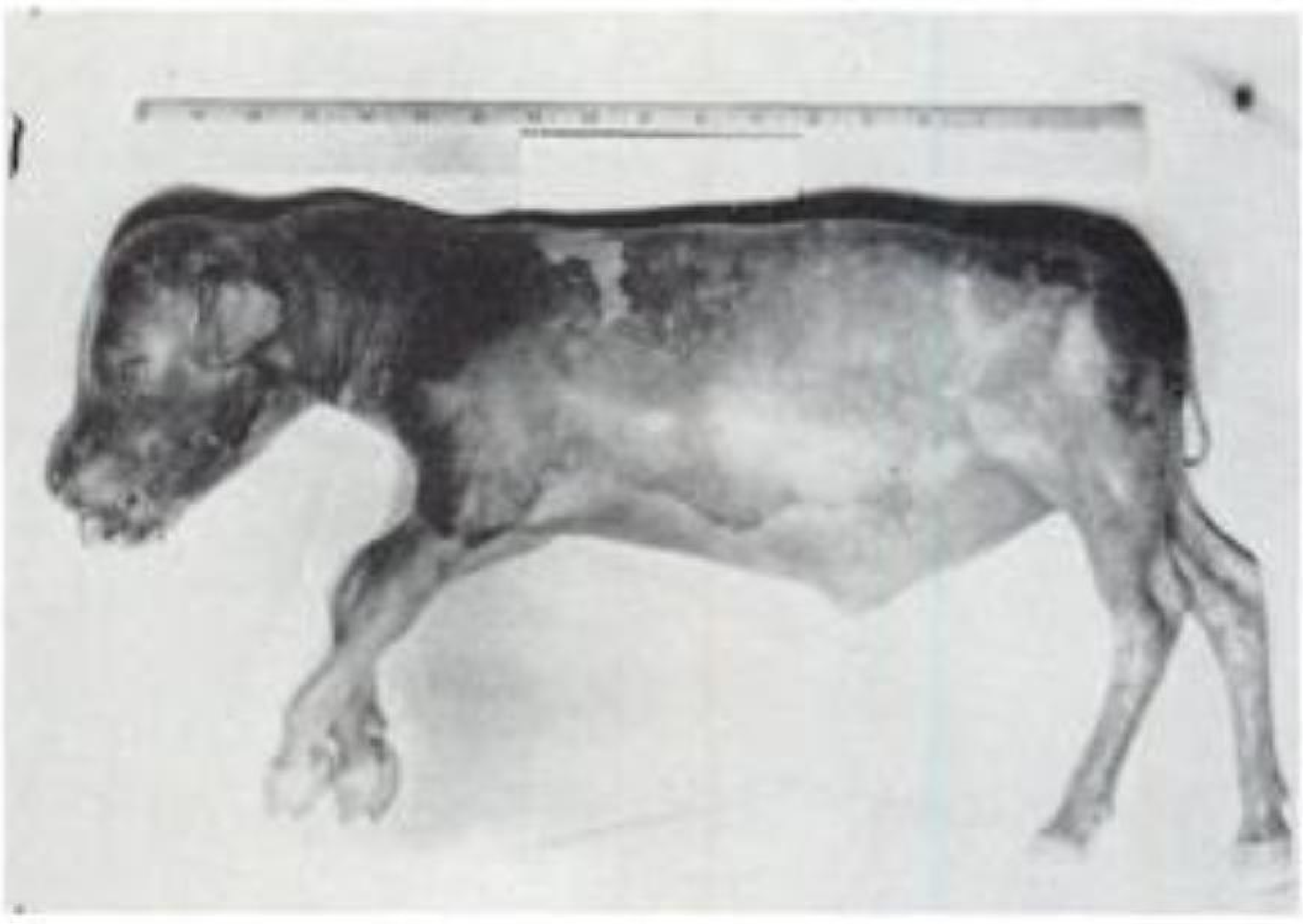
Cows develop an immunity a few months after infection with vibrio. Therefore, any new animals (fresh heifers or purchased additions) added to the breeding herd become infected from contact with bulls. Bulls of 4 or more years of age are true carriers of the disease. Younger bulls may transmit infection from cow to cow, but the organism only will "set-up housekeeping" in the prepuce of older bulls. This becomes an important control consideration. Following an infection, which may or may not cause abortion, some cows remain subfertile and a few become totally sterile.

A vaccine is available to protect cows against vibriosis, but it requires cows to be vaccinated 30 to 60 days prior to exposure to the bull. For most dairy cattle, this would mean at calving or shortly after.

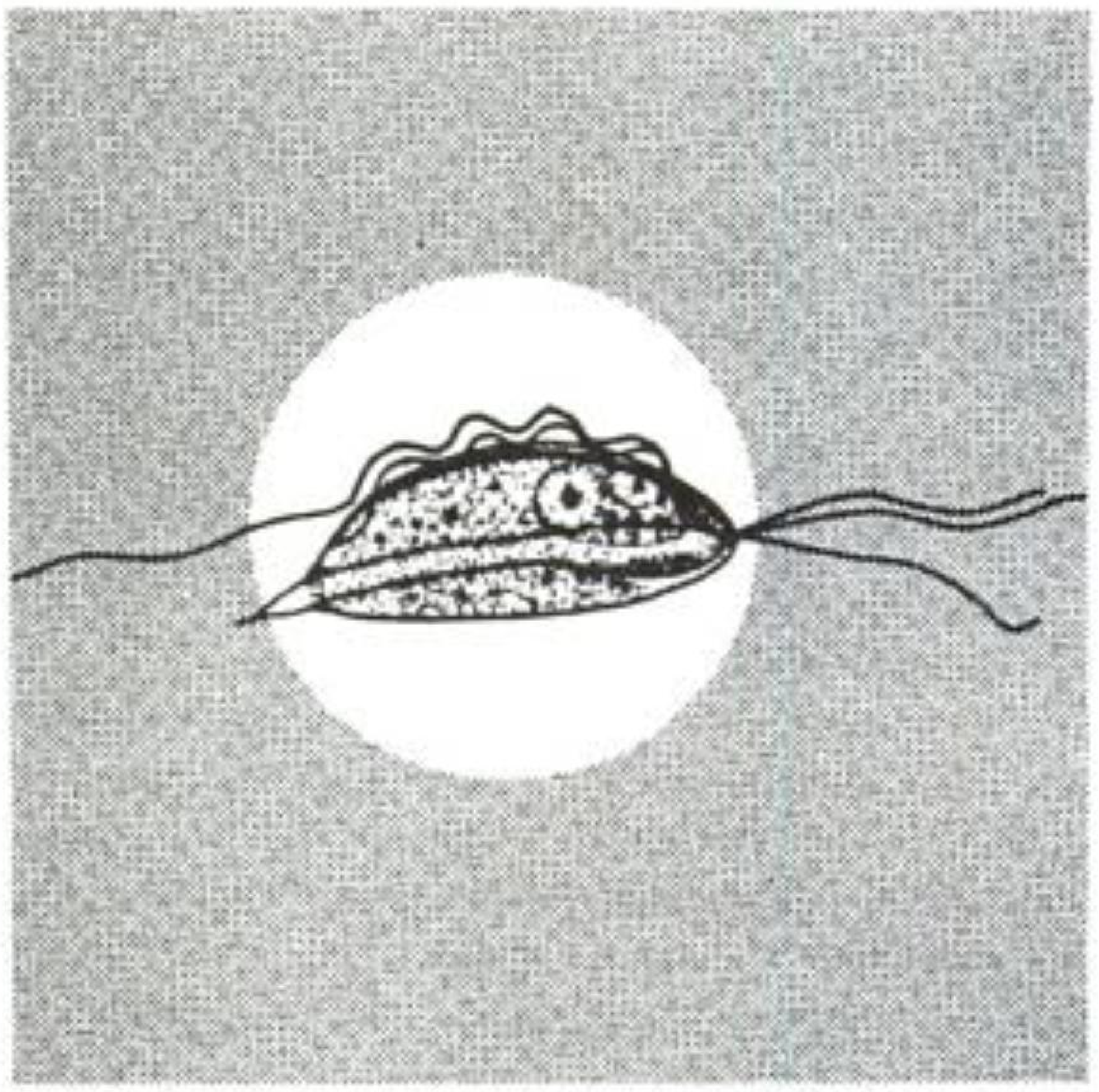
Vibriosis also can be prevented by artificially breeding with semen from recognized bull studs. This method is nearly 100 percent effective in controlling the spread of the disease from the bull to the cow. All A.I. centers certified by the National Association of Animal Breeders (N.A.A.B.) regularly test their bulls for vibriosis and use only vibriosis-free bulls. Look for the letters CSS on the semen straw. These letters stand for Certified Semen Service and represent the N.A.A.B.'s health program.

Trichomoniasis, like vibriosis, became less prevalent with the use of artificial insemination, but with the continued use of bulls on dairy operations, the chance of trichomoniasis causing cattle infertility also continues.

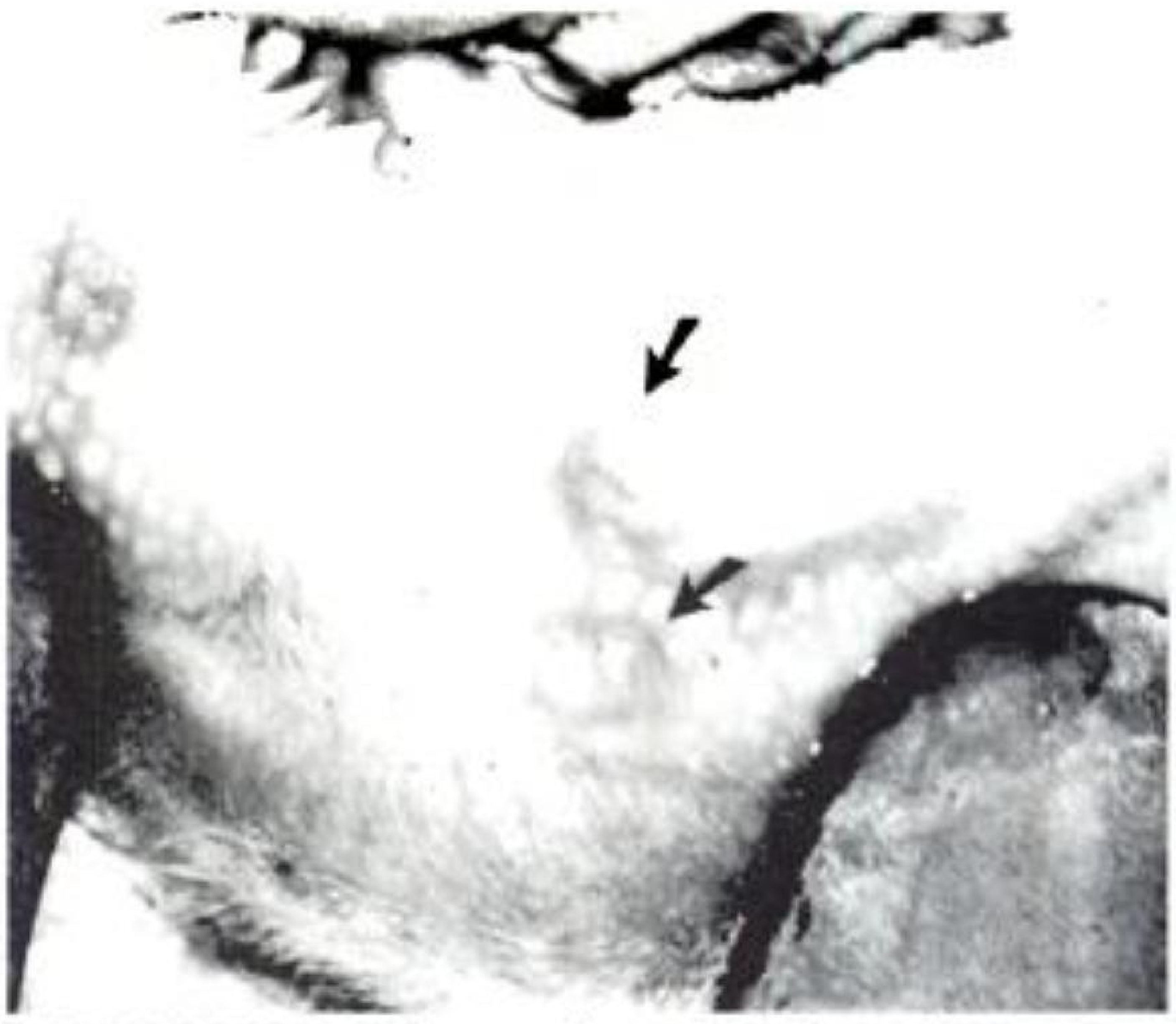
Trichomoniasis is usually transmitted at the time of natural mating. Even though bulls never show external symptoms of the disease, they are usually



CAMPYLOBACTERIOSIS caused this aborted fetus in the fifth month of pregnancy. Most vibrio abortions occur between months four and seven.



TRICHOMONAS FETUS depicted here can be cultured from the prepuce of an infected bull. Note the hair-like tails which propel the organism.



ORAL LESIONS (arrows) may be the only signs present in cattle infected with viral diseases that cause reproductive problems.

may persist for considerable lengths of time. Mating with infected animals can be a route of infection, but only in limited situations.

Symptoms of high fever, lack of appetite, bloody urine and generally poor health are evident in young animals (under 1 year) and are sometimes present in adults. But the clinical syndrome can vary from severe illness to mild signs that go unnoticed. Abortions and stillbirths are the most obvious signs and are associated most commonly with leptospirosis in cattle. Abortions usually occur in the last trimester of pregnancy, 1 to 4 weeks after infection by the leptospira organism. The presence of mastitis that is unresponsive to treatment and blood in the milk of dairy cows should also alert you to the possibility of leptospirosis.

Diagnosis of leptospirosis infection is based on clinical signs, history of abortions, postmortems of stillborn and weak-at-birth calves, and serological testing of the herd. Because of variations in cows' responses to leptospirosis, it is suggested that at least 10 percent of the cow herd be sampled for serological testing to provide an adequate cross sampling of cows. Currently, at least six serotypes of leptospirosis have been shown to cause disease in dairy cattle. Testing should include *L. hardjo, pomona, icterohaemorrhagiae, cantcola, grippotyphosa* and *iszwajizak*.

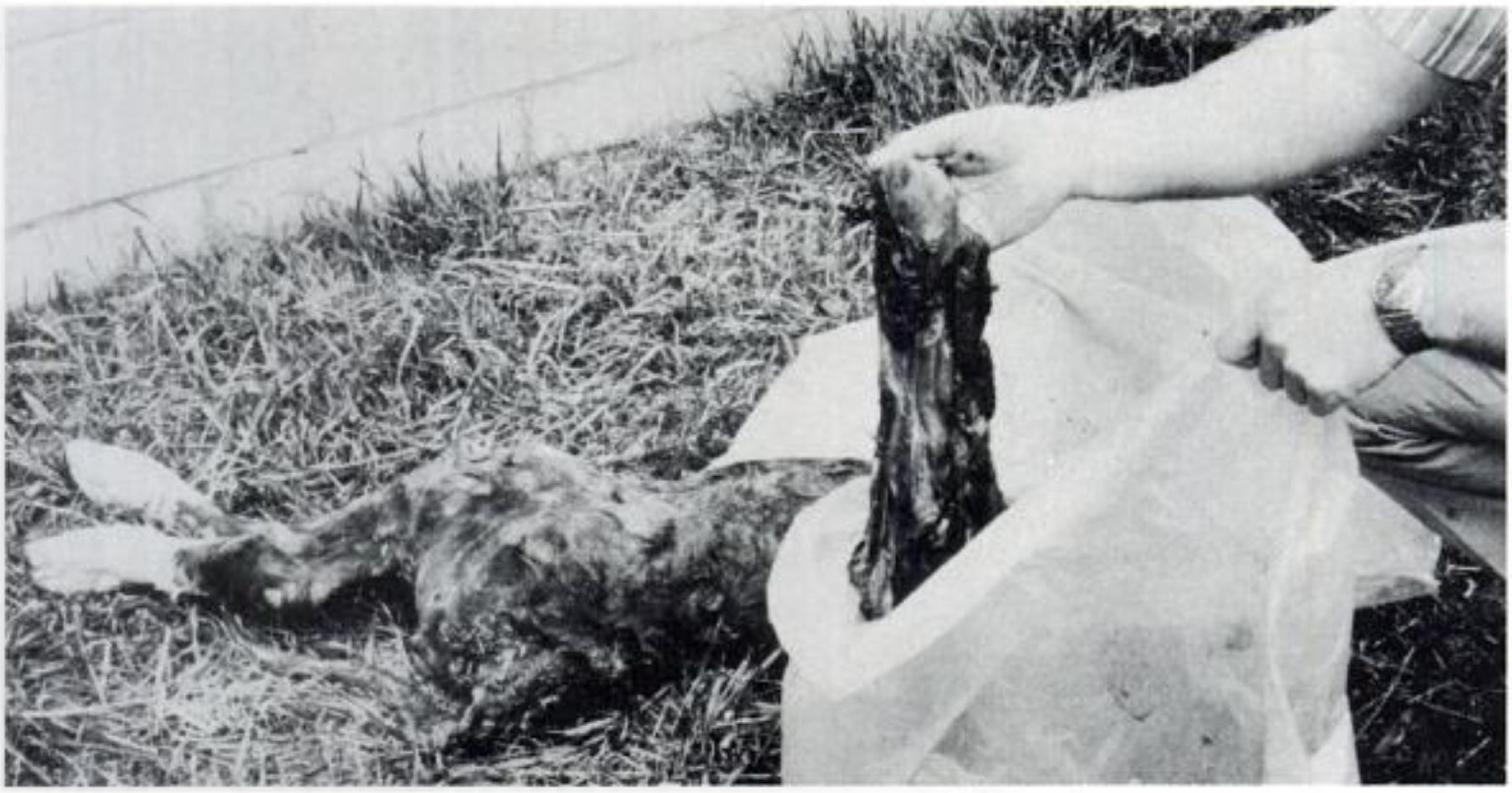
The best form of prevention and control is an adequate vaccination program against leptospirosis. Bacterins are available to immunize dairy cattle against the five major serotypes of lepto, with *iszwadizak* being the lone serotype unavailable in a bacterin. Initial administration of the bacterins should be boostered within 2 to 4 weeks, with subsequent revaccination at 6-month intervals. The vaccination for *hardjo* is minimally protective, so also consider management strategies that reduce exposure to wet areas (ponds, bogs, etc.).

Infectious bovine rhinotracheitis (IBR) is a viral disease that has widespread distribution throughout the United States. There are three forms of the disease seen in dairy cattle:

1. Upper respiratory form
2. Conjunctivitis
3. Infectious pustular vulvovaginitis (IPV)

Exposure to the IBR virus can cause a variety of clinical signs, including combinations of all three forms, or mild inapparent infection that may go unobserved. The upper respiratory form can be manifested in any age animal but is most likely to cause death in animals under 6 months of age. The signs of the upper respiratory form may include high temperature, labored breathing, snotty nose, sharp decline in milk production and lesions of the lining of the oral and nasal cavities.

Conjunctivitis may be the only form of IBR evidenced in a herd, and it is usually associated with increased tearing, reddening of the tissue surrounding the eye and corneal ulcers. IBR conjunctivitis may look similar to pinkeye and is very difficult to differentiate without close examination by a veterinarian.



AN ABORTED FETUS AND PLACENTA should be collected in a plastic bag, refrigerated and submitted for diagnosis of reproductive diseases.

SYMPTOMS OF MAJOR REPRODUCTIVE DISEASES are listed with recommendations for prevention. The use of artificial insemination is one of the most important weapons.

DISEASE	TYPICAL SYMPTOMS	PREVENTIVE ACTION
Bovine Virus Diarrhea	High fever Severe diarrhea Coughing Abortions throughout gestation Fetal anomalies	Vaccination Test herd additions for persistent infection
Brucellosis	Abortions—last trimester of pregnancy Retained afterbirth Increased services per conception Uterine infections	Calfhood vaccination A.I. with CSS semen
Infectious Bovine Rhinotracheitis	High fever Nasal discharge Pneumonia or coughing Pus pockets in the vagina Severe "pinkeye" Abortions—most common in last half of gestation	Vaccination
Leptospirosis	High fever Poor appetite Abortions—most common in last third of gestation Bloody urine Anemia Ropy and/or bloody milk	Periodic vaccination Keep cattle separated from other classes of animals
Uterine infections	Discharge of pus Foul odor of uterine discharge Veterinary palpation of large, flabby uterus Retained fetal membranes Repeat breeders	Careful sanitation at calving Intrauterine therapy Routine postpartum examinations
Trichomoniasis	Abortions first trimester of pregnancy Uterine infections Irregular heat periods Several services per conception	A.I. with CSS semen Testing of bulls Vaccination
Campylobacteriosis	Abortions second trimester of pregnancy Several services per conception Irregular heat periods	A.I. with CSS semen Vaccination Testing of bulls
Neospora (bovine protozoal abortion)	"Abortion storms" at 5-7 months gestation or abortion at any time	No recommendation at this time

Fungal and other sporadic infections of the placenta cause abortion by decreasing the placental functions of fetal nourishment and waste control.

A bacterial disease, ureaplasmosis, has been associated with a repeat breeding and occasional abortion syndrome. This agent causes an infectious, granular-appearing vaginitis and is subsequently inoculated into the uterus during artificial insemination by the insemination pipette. Diagnosis is difficult and may be confused with an IBR virus infection. Vaginal contamination of the A.I. pipette is prevented by covering the pipette with a plastic sheath.

A deficiency of the trace mineral selenium has been associated with abortion, retained placenta, endometritis and cystic ovaries. Feed analysis and serologic testing are aids in diagnosis. Short-term supplementation may be accomplished with injectable products, but a longterm solution involves ration balancing.

Preventive measures. The dairy producer who is faced with an infertility problem in the herd should first eliminate disease as a cause before considering other causes. Rapid diagnoses are essential to minimize the extent of infection in the herd, and also to minimize the damage to each individual cow. Periodic veterinary examinations detect diseases early.

Diagnosis of abortion is frustrating to dairy producers and to veterinarians because many times the calf is too decomposed to make a diagnosis. Samples to submit include the fetus, placenta and blood from the cow. Keep these samples chilled until your veterinarian or diagnostic lab personnel evaluate them. Multiple fetuses often are needed to make a diagnosis.

Artificial insemination is another tool to help prevent disease. Bulls in most A.I. organizations are checked for diseases before they enter the stud. Thereafter, they are tested periodically. If the dairy producer employed similar preventive measures in herd management, most reproductive diseases could be reduced drastically.

CALFHOOD VACCINATION provides protection against brucellosis and is a practice all dairy producers need to consider.

Isolation prevents spreading. In general, disease organisms (bacteria, viruses and protozoa) perish without host animals. This fact is the reason why isolation of diseased animals is so important.

The organisms responsible for most reproductive diseases die rapidly (or, at least, lose their potency) when they leave the animal's body and are exposed to dry air. However, survival outside the body is enhanced by filth, especially when moisture is present to provide a favorable environment.

Isolation pens should be far enough away from the main barns to prevent direct exposure of suspect animals to the rest of the herd.

The length of time an animal must be isolated to insure the safety of the rest of the herd depends upon the nature of the infection. There are no blanket recommendations. Instead, rely upon your veterinarian's recommendation for each case.

During isolation, utensils and tools used for infected animals should not be used for the rest of the herd. Wash your hands thoroughly with soap and water, and disinfect footwear before leaving the isolation area.

After a diseased animal is removed from isolation, the pen should be scraped and thoroughly washed with soap and water. The pen should then be sprayed or rinsed with a disinfectant and left vacant for at least two or three days. During this time, most remaining organisms will die because of dryness, provided no manure remains to protect them.

These recommendations are time-tested. But in view of the price squeeze on the dairy producer, they are at least as important today as they ever have been.

treatment, reproductive performance and milk yield often were reduced. This illustrates an important principle when dealing with fresh cow health disorders – an ounce of prevention is worth a pound of cure.

The list of disorders is headed by a general category of "abnormal health status" that includes more than one-third of all cows in herds that are afflicted with two or more of the remaining health problems, making it difficult to put in a category. These problems increase the risk for culling and death by two to five times. Beyond this, milk production and reproductive performance are affected noticeably.

Cleaning is important. Uterine infections and other infections of the reproductive tract are prevalent in about one-fifth of all cows early after calving. Several other disorders, including milk fever, retained placenta, displaced abomasum and ketosis add to the cow's risk of having uterine disorders.

In addition, twinning, stillbirth, prolonged gestation, induced parturition, calving difficulty and overconditioning during the dry period generally raise the incidence of metritis. The studies report milk losses of 2 to 5 percent, and reproductive performance is reduced because calving intervals are prolonged. These reproductive tract infections increase the risk for other disorders, including displaced abomasum, ketosis and acidosis in cows that had a retained placenta.

Ovarian cysts, follicular or thin-walled and luteal or thick-walled, are found in about 12 percent of cows, mostly in the second month after calving. Occurrence of cysts has a higher heritability than milk production, suggesting that keeping cows or daughters of cows with cystic ovaries is not advisable. High production does not cause cystic ovaries, but its incidence increases with age and during winter months.

Ovarian cysts make culling and poor reproductive performance more likely. Endocrine imbalance seems to explain the occurrence of most cysts, and their treatment can be resolved by gonadotropin-releasing hormone (follicular cysts) or prostaglandin (luteal cysts).

Calving difficulty, twinning, stillbirth and retained placenta are associated calving problems. Large calves, male calves, twins, malpresentations and stillbirths are associated with calving difficulty. All of these are more frequent in heifers and young cows.

Watch problem calvers. Calving difficulty boosts the risk of retained placenta, uterine infections, culling, death, milk fever and cystic ovaries. Twinning increases risk for stillbirth, retained placenta, uterine infections, displaced abomasum and culling. Similarly, retained placenta makes uterine infections, ketosis, displaced abomasum and culling more likely. Therefore, all of these disorders are interrelated and reduce reproductive performance of cows.

Although milk fever occurs about 6 percent of the time, its incidence is highly preventable. Older cows and all cows with high milk production are at risk. Some studies suggest that feeding more protein early in the dry period, less phosphorus and calcium during the dry period and lead feeding in the late dry period will prevent milk fever. Although in general it may be treated easily, milk fever adds to the risk for calving difficulty, retained placenta, ketosis and possibly mastitis, even though it may not precede the clinical signs of these disorders.

The table's summary of the effects of these disorders on reproductive performance and milk yield is alarming. Each disorder cited, except mastitis, hurts fertility and reproduction directly or indirectly.

Milk yield was reduced most significantly in cows that required surgical assistance at calving because of stillbirth. However, there were some losses of milk as a consequence of retained placenta, uterine disorders, twinning, cystic ovaries and in cows with generally abnormal or poor health.

Most disorders occurred in combination with other disorders, rather than as a single problem. In other words, cows with one disorder were at greater risk for other problems. There is a strong interrelationship of reproductive and metabolic disorders.

Fortunately, actual milk yield or the potential for high production does not appear to be a cause for any of the disorders, except milk fever. This is encouraging because milk fever may be the only disorder that is preventable most readily by good dry cow management.

One last, clear message in the literature is that measures taken to prevent one or more of these disorders probably will decrease the risk and incidence of other related problems, as well. More research is needed to better understand the causes and preventions of these disorders, thus allowing better designed preventive herd health and dry cow management on the farm to improve the general health and productivity of dairy cattle.

Chapter 13

Improving management

WE HAVE STRESSED the critical importance of heat detection, timing of insemination, feeding and disease control in beating the infertility problem. These factors are important, but there are other management errors that upset the reproductive process. In many herds, these mistakes are the prime source of breeding headaches.

Before getting into these "herdsmanship" items, we would make one strong point—it has to do with artificial insemination. We find it difficult to understand why approximately 15 percent of our dairy cows and one-third of our dairy heifers still are bred by natural service. In the vast majority of our herds, milk production could be improved rapidly by use of proven bulls through A.I. And as we pointed out in the Chapter 11, the danger of reproductive diseases is reduced greatly when a bull is not used.

The merits of A.I. are so convincing that many progressive breeders who keep bulls now use artificial insemination with semen from their own bulls. They have a breeding organization collect and store semen from the desired bull.

In all probability, a great majority of dairy producers with bulls in natural service could increase profits by selling the bulls and using A.I.

Accurate heat detection is key. With the advent of artificial insemination, the dairy producer replaced the bull in the job of finding cows in heat. Herein lies the greatest management error which hinders maximum herd fertility. A person now assumes complete responsibility for heat detection. When this important management practice is done improperly, the cow makes you pay.

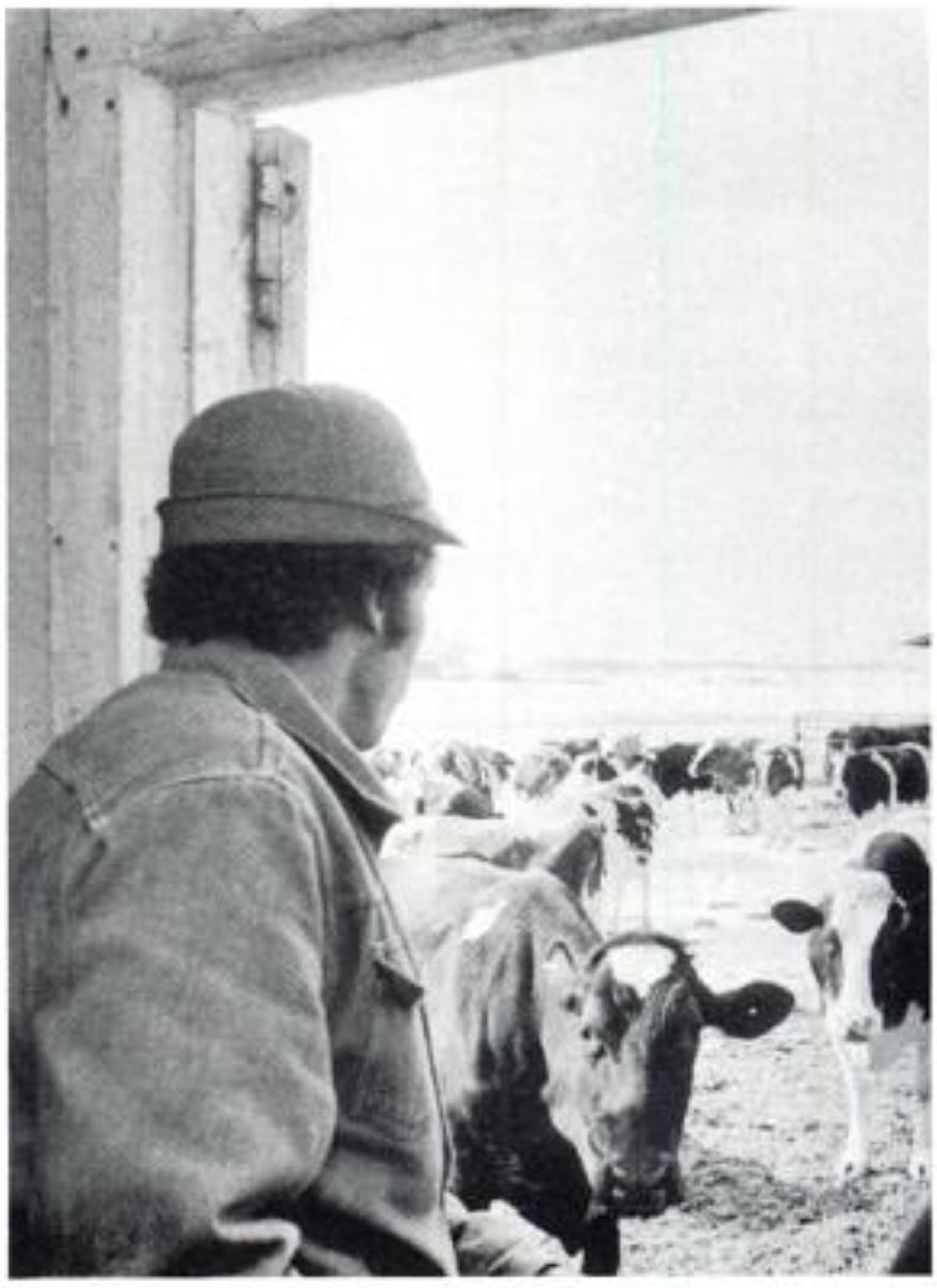
Monetary losses cited in the first chapter verify that it costs something to do nothing! It is especially true of failure to observe cows in heat.

We discussed signs of heat previously (page 35). Standing heat is the best sign to look for. There are differences between cows in the expression of heat signs, and an individual cow's behavior may vary from one heat to the next. Yet despite cow differences, **there are greater differences between people in their ability to detect heat signs.** Some persons working with cattle excel in detecting heat. They are keen observers and even at a great distance, can pick out unusual behavior in some animals. Yet there are others who might walk right beside a cow having a calf and never notice any unusual behavior.

When cows are observed closely, it is rare to discover suddenly that one is in standing heat without any prior warning. **If, from each cow's previous behavior, it is not known that she is coming into standing heat, then the cows are not being watched frequently enough.**

There is ample evidence that alertness and close observation pay dividends in heat detection. A Minnesota study of over 2,500 cases classified as anestrus (silent heat) showed that 90 percent of these cows had functional ovaries and were actually cycling. Most likely, the "anestrus" label resulted from missed heat signs caused by poor management.

An Idaho study showed that the intensity (or degree) of estrous signs shown by cows



COWS COME IN HEAT in any weather. Turning cows out in winter will help heat detection.

varies as does the length of estrous cycles. Despite the low intensity or "silent" estrus in some cows, the long-term study in Idaho showed that good records, proper training and more careful observation enabled the herd manager to detect more cows in standing heat at some time during estrus.

The fertility of cows with low intensity of estrus was not impaired. No doubt, a good system of records and closer observation of cows could result in an increase of 10 to 20 percent in breeding efficiency in many herds.

Some cows may have short heat periods, which may be missed unless they are observed twice a day. **Observe cows for heat at least twice daily at times other than when they are being milked or being fed.**

Several studies have confirmed that more cows are first detected in heat in the early morning than in the afternoon. A possible reason is cows are more free to interact in the morning because they are not busy eating, being milked or being moved. Further, a cow in heat will be mounted more frequently if there are one or two other cows in heat at the same time. **For this reason, cows in heat should not be separated from the rest of the herd.**

Management problems associated with heat detection are magnified in larger herds. It is not unusual for critical reproductive problems to come to the forefront in recently expanded dairy herds. As a rule, better records and more attention will solve the problem.

One person should be given the responsibility for heat detection. Be certain that this person is aware of the signs of heat and knows the characteristics of individual cows.

Normal cows (those having no difficulty at or shortly after calving) usually will ovulate within 10 to 20 days after calving. But usually no more than half of the cows will show signs of heat at the beginning of the first cycle. At the second cycle after calving, about 80 percent of the cows will show signs of heat. The first heat cycle (interval between first and second ovulation) after calving is likely to be shorter than usual, averaging about 17 days.

Thus, normal cows usually will have one to two ovulations, "heat periods," during the first 30 to 35 days after calving. Though the first heat period may be "silent," many of these heats can be detected if the cows are observed closely. This should be used to indicate normal cycling cows.

Abnormal cows (those having calving trouble, twins, retained afterbirth, metritis, milk fever, and so forth, at calving or within seven days after calving) may not show heat nor ovulate as soon as normal cows.

More than half of all cows should show signs of heat by 30 days, and at least 90 percent of the cows should show standing heat by 60 days after calving. **Any cow not observed in heat by 45 days after calving should be examined.** In fact, a postpartum examination of each cow at 20 to 40 days after calving is a good management practice.

The exam will determine if a cow has recovered from calving and if the ovaries are functioning properly. Many reproductive disorders can be detected and cleared up soon enough to get the cow inseminated by 60 to 90 days after calving.

Irregular heat cycles. Occasionally, cows may show abnormally short or long estrous cycles. **Definitely do not breed a cow after an irregular cycle if there are signs of other abnormalities, such as an abnormal discharge.** But suppose the cow is examined and found to be normal except for the irregular cycle. Experiments have shown that the fertility of inseminations of such cows is somewhat below normal. Nevertheless, there seems to be little to lose but a straw of semen.

Consequently, we recommend that a cow showing an irregular cycle be thoroughly examined first. Then, provided there is no evidence of infection or disease, inseminate the cow. Remember, fertility at this time is lower than that normally expected.

Check for pregnancy. Most dairy producers assume a cow is pregnant if she does not return to heat within a reasonable period of time after breeding. This assumption is a good one in the majority of cows. However, uterine infections, cystic ovaries, embryonic mortality, several diseases and other disorders make the assumption dangerous in some cows.

Most A.I. organizations assume a cow has settled if she does not return for another service within 60 to 90 days. This measure, called a "nonreturn rate," is used in calculating the fertility level of bulls in A.I. service.

A 70 percent nonreturn rate on a bull in A.I. simply means that 70 of every 100 cows bred to the bull did not return for a second service within 60 to 90 days.

Since most A.I. organizations originally included a second and third service in the price of the first service, they felt that the technician would be called back to breed the cow again if she returned to heat. Thus, if the technician was not called to rebreed the cow, she was assumed pregnant. This assumption is not completely accurate because of culling, use of natural service and primarily because of poor heat detection.

But nonreturn rates give inexpensive and quick feedback of fertility information to the A.I. organization, and a relative ranking of bull fertility and technician skill.

Nonreturn rate is being used less as a measure of fertility because fewer of the inseminations are being made by professional technicians employed by A.I. organizations. When inseminations are made by the herd manager, the nonreturn information is seldom made available to the A.I. organization.

Pregnancy diagnosis is the most reliable measure of conception. Skilled veterinarians can detect pregnancies by rectal examination beginning about 35 days after insemination. This is a delicate process and is best performed by a professional. It is not a procedure to be practiced by the average individual.

Milk progesterone testing. A management tool available to dairy producers and veterinarians is simple and rapid progesterone testing of milk. Accurate and easy to use, on-farm milk progesterone tests are an important technological advance. Milk progesterone testing makes it possible to accurately monitor the reproductive status of cows in daily management and assist in diagnosing herd reproductive problems.

Milk progesterone testing **should not** be used as the sole means of pregnancy diagnosis. The accuracy of pregnancy determination from a single high progesterone sample taken on the 21st, 22nd, 23rd and 24th day after breeding is only 75 percent. In contrast, open cows can be determined with 95 to 100 percent accuracy with a low progesterone result during this period.

Therefore, testing to identify open cows for rebreeding is the best approach; however, the sample should be taken 20 days after breeding instead of 21 to 24 to allow time for close observation and rebreeding.

Progesterone concentrations in milk are closely related to events of the estrous cycle (see figure). Progesterone is at its lowest level around the time of heat, and at its highest level with maturation of the CL (12 to 15 days after heat). When a cow is not inseminated or fails to conceive following insemination, the CL regresses and progesterone levels decline 2 to 3 days prior to the next heat. In contrast, when breeding results in conception, the CL is maintained, the cow does not return to heat, and progesterone remains elevated throughout pregnancy.

Procedures for performing on-farm milk progesterone tests are specific for each test; however, the principles of the assay are similar. On-farm tests are designed to determine if progesterone concentrations are "low" or "high" rather than providing a precise concentration.

It is important that the instructions are followed exactly and shortcuts are not taken. It is also important that you use the type of sample specified in the instructions. Most tests require foremilk or first-milk samples, but postmilk or last-milk is required for at least one test.

Applications of milk progesterone testing. Accurate detection of heat is essential for successful use of artificial insemination. Numerous field studies have shown that about 15 percent of all cows inseminated are not in heat at the time of breeding. A high milk progesterone result reveals that the cow was not in heat and should not be bred. It is recommended that a milk progesterone test be performed after heat is suspected when detected solely by secondary signs or mechanical detection aids and for cows previously diagnosed pregnant.

Low progesterone test results cannot be used to predict when to breed. Progesterone levels are low for approximately six to eight days (two to three days before heat and three to four days after heat).

Only half of the heats are detected on dairy farms in North America. A low progesterone result from a sample collected 19 to 24 days postbreeding is practically 100 percent accurate in identifying an open cow. Recommendations are to collect a milk sample 19 or 20 days postbreeding on all cows open greater than 100 days. If a low result is obtained, heat observations should be intensified and/or heat detection aids such as tailhead chalk or rump mounted detectors applied.

Additionally, in conjunction with your veterinarian, other areas of the reproductive management program can be evaluated, such as assessment of heat detection accuracy, monitoring postpartum cyclicity, evaluation of early embryonic death, differentiation of ovarian cysts, and monitoring response to infertility treatments.

Milk progesterone testing alone cannot be used to determine if a cow has a cystic ovary. However, once the presence of an ovarian cyst has been determined by rectal palpation, your veterinarian can use milk progesterone testing to help distinguish the type of cyst present.

There are two major categories of ovarian cyst: follicular cyst—thin walled, estrogen producing; and luteal cyst—thick walled, progesterone producing. Variation in the amount of cyst wall luteinization makes follicular and luteal cyst types difficult to distinguish by palpation.

Cows having a low progesterone concentration are considered to have a follicular cyst, and those with high concentrations are regarded as luteal cysts. Proper treatment requires the correct diagnosis.

Heat detection aids. Accuracy of heat detection is the percentage of heats observed that are true heats. Accuracy would be 90 percent if 9 of every 10 cows inseminated were truly in heat when bred. The ability of dairy personnel to interpret the signs of heat correctly, and therefore to detect cows in heat accurately, is highly variable and has a significant affect on conception rate.

A Cornell study reported that over 5 percent of cows presented for insemination were not in heat based on milk progesterone levels – and in almost a third of the herds surveyed, the number of cows not truly in heat was 10 percent. Most of the cows bred that were not in heat were detected by either secondary signs or with detection aids. Insemination of cows not in heat results in unacceptable fertility.

The goal of using heat detection aids is to increase the efficiency of heat detection without decreasing the accuracy.

Heat detection aids used in dairy herds today vary from heat expectancy charts and tail chalk to electronic pedometers and pressure sensors. Heat expectancy charts are special calendars used to record breeding and heat information. Heat expectancy charts are available from most A.I. organizations and **should be used to generate a weekly heat expectancy list of cows that have the best likelihood of coming into heat.**

Pressure-sensitive mount devices are probably the most commonly used aid other than the heat expectancy chart. Mount devices are glued to the tailhead and activated by the weight of another cow mounting the cow on which the device is attached. Activation changes the device's color from white to red or from white to green, depending on the brand.

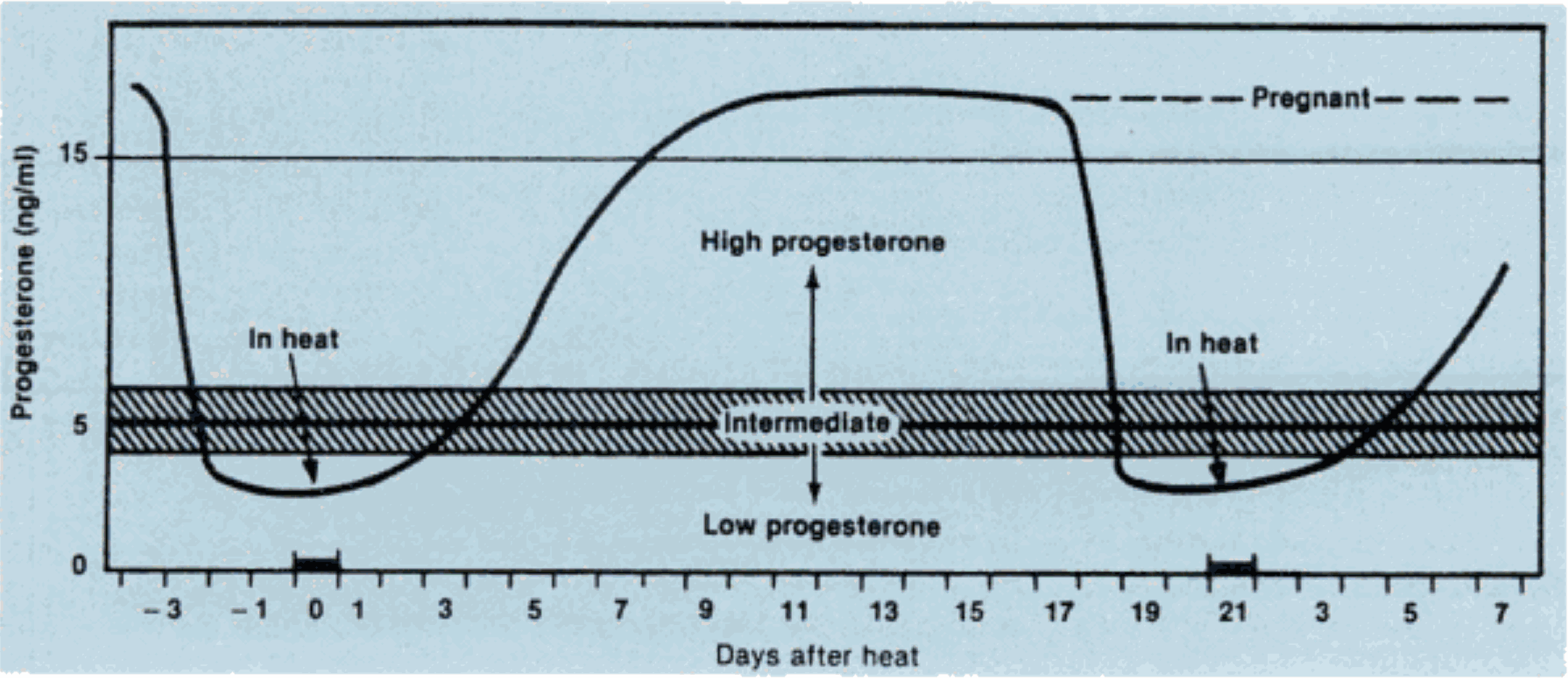
Tail chalk, crayon and paint are often used in larger herds. A cow that has been mounted has the chalk or paint rubbed off or smudged. Chalk or paint appears to be as effective as pressure-sensitive mount devices, while being less expensive. The disadvantages of chalk or paint are:1) cows need to be rechalked as often as every 2 to 4 days; 2) chalking may require restraint of the cow; 3) false smearing of chalk may occur.

Detector animals are commonly used in herds over 100 cows. Two types of detector animals are surgically altered bulls and hormone treated heifers or cows. Detector animals are sometimes fitted with a chin-ball marking device which leaves a colored fluid on any cow that is mounted. The advantage of a chin-ball marker is that cows in heat need not be observed "standing."

Vasectomized bulls are altered surgically so that mating may occur, but sperm transport is blocked. Gomer bulls are altered surgically to prevent contact between the penis and the cow. Most commonly, the pathway of the penis is altered so that it exits to the side of the bull so he cannot service the female.

The advantage of using an altered bull as a dectector animal is that most cows in heat will be mounted. Also a more intense heat is usually displayed by cows exposed to a bull. No more than 30 to 40 open cycling cows should be grouped per bull for efficient detection. The disadvantages of using a surgically altered bull include: 1) danger of

Normal pattern of progesterone in milk during the estrous cycle



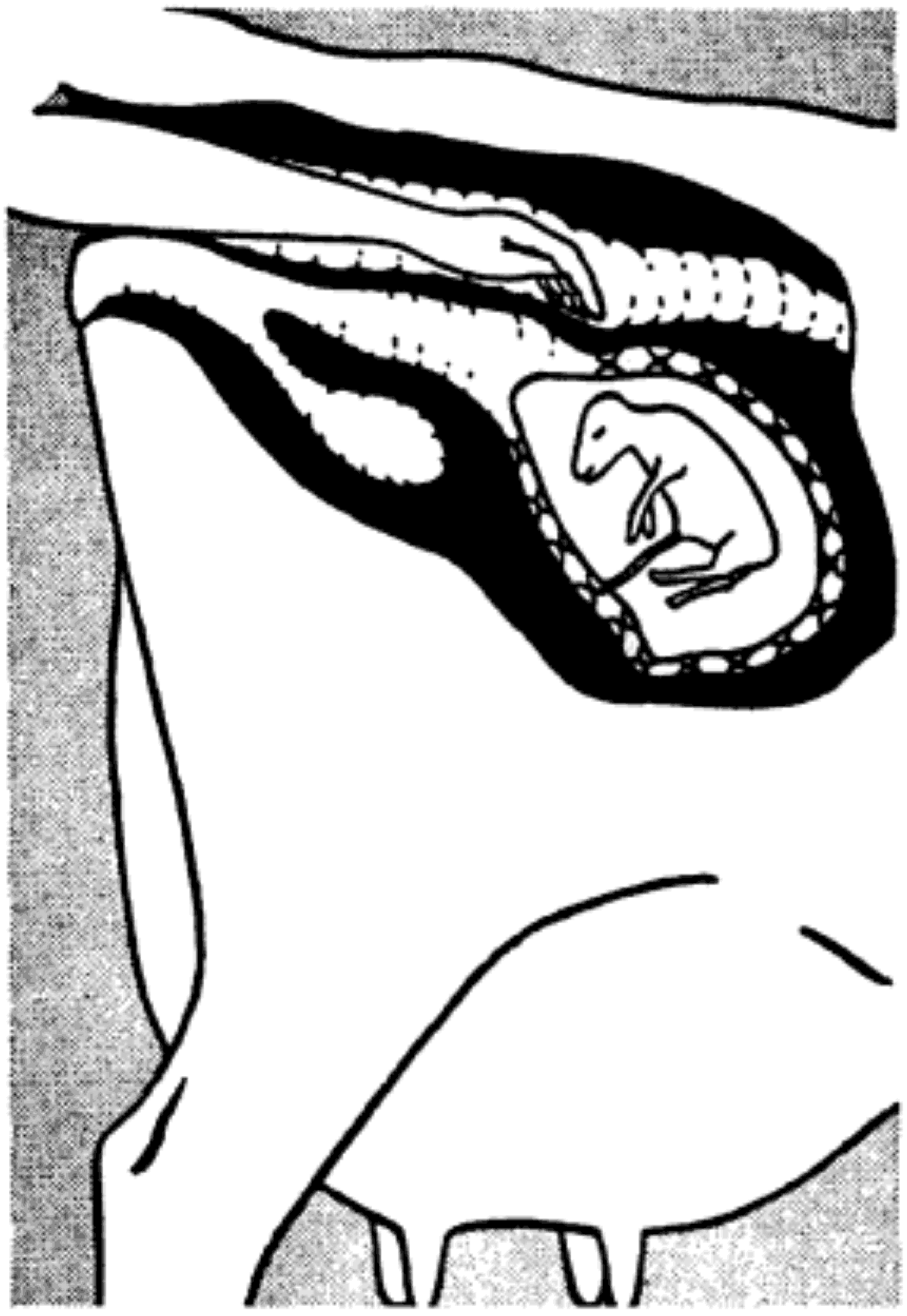
an aggressive bull in the herd; 2) feed cost of maintaining a bull; 3) transmission of venereal diseases by a vasectomized bull; and 4) a decrease in sex drive over time with some gomer bulls.

Cows or heifers treated with testosterone or a combination of testosterone and estrogen may be used effectively as heat detector animals. However, only 50 to 75 percent of injected animals will respond to treatment. The main advantage of using a hormone-treated animal is that nearly all cows in heat will be mounted. It is not known if the heat period is more intense for cows exposed to a hormone-treated animal. Stocking rates for hormone-treated animals are similar to those for bulls.

New types of electronic heat detection systems are becoming available. Two devices currently being used measure either increase in physical activity (pedometers) or mounting activity (electronic pressure sensor-transmitters). Research has reported that cows in heat are more active and typically walk 2 to 5 times farther compared to the nonheat period. All pedometers available allow for comparison of activity within individual cows which increases the accuracy of these devices. Overall, the advantage of pedometers seems to be continuous monitoring 24 hours a day. However, adverse weather, restriction of activity or type of housing can influence activity and lower accuracy of pedometers in determining the onset of heat.

An electronic pressure-sensoring system which transmits radio waves to give mounting activity information instantly is the newest system available for heat detection. Studies at Virginia Tech over the past 5 years have revealed that the average heat period consists of 10 mounts over an 8- to 10-hour period. Heat detection accuracy was reported at 95 percent, and efficiency at 91 percent. Labor for maintenance and installation of transmitters and review of computer-generated management lists averaged 25 minutes per day, about half the labor required for visual detection of the same number of cows. **Perhaps most important, for the first time the precise onset (first mount) of "standing" heat can be identified, thus allowing accurate timing of insemination.**

Ideally, these new devices and others that will be developed will provide assistance to the challenges of catching cows and heifers in heat. Any new heat detection system needs to be integrated into the daily reproductive management of the herd. These systems will require both an initial investment of money and time to improve the heat detection of the herd.



PREGNANCY CHECKING by a skilled veterinarian may be accurately performed 45 to 60 days after breeding. He does this by rectal palpation of the main uterine artery, which enlarges in proportion to the growth the fetus. He also palpates for cotyledons, membrane and the fetus. No single criterion is accurate because of the large variation among cows.

Have examination. Most dairy producers will find it profitable to have a skilled veterinarian routinely check for pregnancy on a monthly or bimonthly basis. Dairy producers who have adopted the practice of regular veterinary checks report that many reproductive disorders can be detected during the examinations. Certain infertilities can be avoided and losses from maintaining sterile cows can be minimized.

Failure to have pregnancy diagnosis may result in another serious loss. Pregnant cows occasionally show a heat period, even after five or six months of pregnancy. **Surveys have shown that about 50 percent of the cows slaughtered for sterility are in calf at the time of slaughter.** Many would not have been slaughtered had the owners known the cows were pregnant.

These pregnancy examinations of cows showing heat five or six months after breeding can be made by the veterinarian at the time of his regular visit.

Like the pregnancy checks at 30 to 60 days after breeding, these are not jobs for the average person. Skilled herd managers may become proficient in this technique in their own herds, but it is a delicate process and requires a great deal of skill and experience.

Chapter 14

Management tips & records

UNDER PRACTICAL FARM CONDITIONS, a herd may have no reproductive disturbances for several months. Then, suddenly, an abortion may occur or one or two cows cannot be settled even with the best treatment.

Your first question should be: Do these cases pose a threat to the rest of the herd, or are they caused by failure of the normal physiological mechanisms?

Suppose a few cases of infertility show up in a herd. Are they cause for alarm or should they be expected periodically?

Surveys have shown that **about 8 to 10 percent of our dairy cows are culled for infertility each year**. About half of these may represent a serious threat to the reproductive health of the rest of the herd.

Certainly, the remainder of the infertile cows result in serious losses, but they apparently will not pass on their infertility to other cows. About half of the "non-spreaders" will recover spontaneously, with no treatment other than time.

OBSERVATIONS MADE in the feedlot or out on pasture should be noted immediately and then entered into the cow's permanent record.

From these considerations, you may conclude that a certain amount of infertility among dairy cattle is unavoidable. The question then becomes: What level of fertility or infertility can be expected from a well-managed herd of dairy cattle?

Here are some reasonable goals to strive for. They are characteristic of a well-managed herd.

1. At least 60 percent of the cows should conceive at first breeding.

At least 50 to 55 percent should have a normal calf from first breeding.

The difference between conception and calving percentages is due to fetal deaths, normally expected.

2. At any given time, there should be no more than 10 percent of the cows with reproductive difficulties.

3. At the end of a year, the herd should average no more than 1.7 to 2.0 services per conception. After fetal deaths are considered, this is roughly equivalent to about 1.9 to 2.2 services per calf born. For example, a 50-cow herd should require no more than 85-100 services for all of the cows to produce calves.

These are averages for the well-managed herds. Many herds achieve higher fertility, at least for a year or two. There is no good reason why the average for all dairy herds could not be as high. There is ample evidence that sound management is the key to high fertility.

Danger signals. The alert herd manager will take great care to watch the cows daily for behavior that is not normal. The following symptoms are danger signals, probably indicating serious reproductive disturbances:

1. An open cow that does not show heat.

2. An abnormal discharge (pus) at any time. Discharges from the vagina should be clear. The only exceptions are the minor bleeding that occurs just after heat in some cows, or the bloody discharge during the first two or three weeks after calving.

3. Heat intervals less than 15 days or more than 28 days.

4. Heat intervals of irregular

length.

5. Prolonged, continuous heat symptoms.

6. Cows with more than three services.

7. Abortions at any time.

8. Retained afterbirth.

Any one of these signs could be an indication of real trouble. They do not necessarily indicate a disease. However, infectious diseases are the reason for about half of the cows showing one or more of the above symptoms.

But even if the symptoms are due to noninfectious causes, rapid action is important to help prevent permanent sterility and minimize financial loss. Our recommendation is to have a regular herd health program so the veterinarian detects most abnormalities soon after they occur.

We repeatedly have emphasized the complicated nature of reproduction. It is exceedingly unlikely that any dairy producer can become very proficient in the exacting methods of diagnosis and treatment of infertility. It is too much to expect of any person who is also required to keep up to date on soil management, crop management, husbandry, marketing, economics, engineering and other areas.

Certainly, qualified herd managers in many of the large herds must take on some of the chores, such as dehorning, removing extra teats from calves, and perhaps some vaccination. Unless this employee has a great deal of expertise, however, it may be wise to let the veterinarian handle the herd health problems, including infertility. It is a veterinarian's job to keep abreast of new developments.

What the veterinarian needs. When your veterinarian comes for a regular herd visit or to check a cow that does not settle, he or she must do more than just look at her and take blood or urine samples. The complete history of the cow must be available: Birth date, calfhood disease vaccinations, heat period dates, and breeding and calving records are all important. These records should be readily available and accurate.

In addition, the veterinarian will want to know if the cow was off feed, down in milk, had any other disease or was exposed to other cows. The type of pasture or hay and silage, the source of water and the composition of the grain mixture are important, also.

Restlessness, abnormal discharges, length of previous gestations, retained placenta, calving difficulties, fever, abnormal odors, lameness, stiffness, swelling or discolorations are still other observations that can be helpful.

Unfortunately, when the veterinarian asks these questions, most dairy producers give opinions and guesses. Exact records of the herd manager's observations of cows seem to be lacking on many farms. Undoubtedly, this management error is responsible for many cases of infertility.

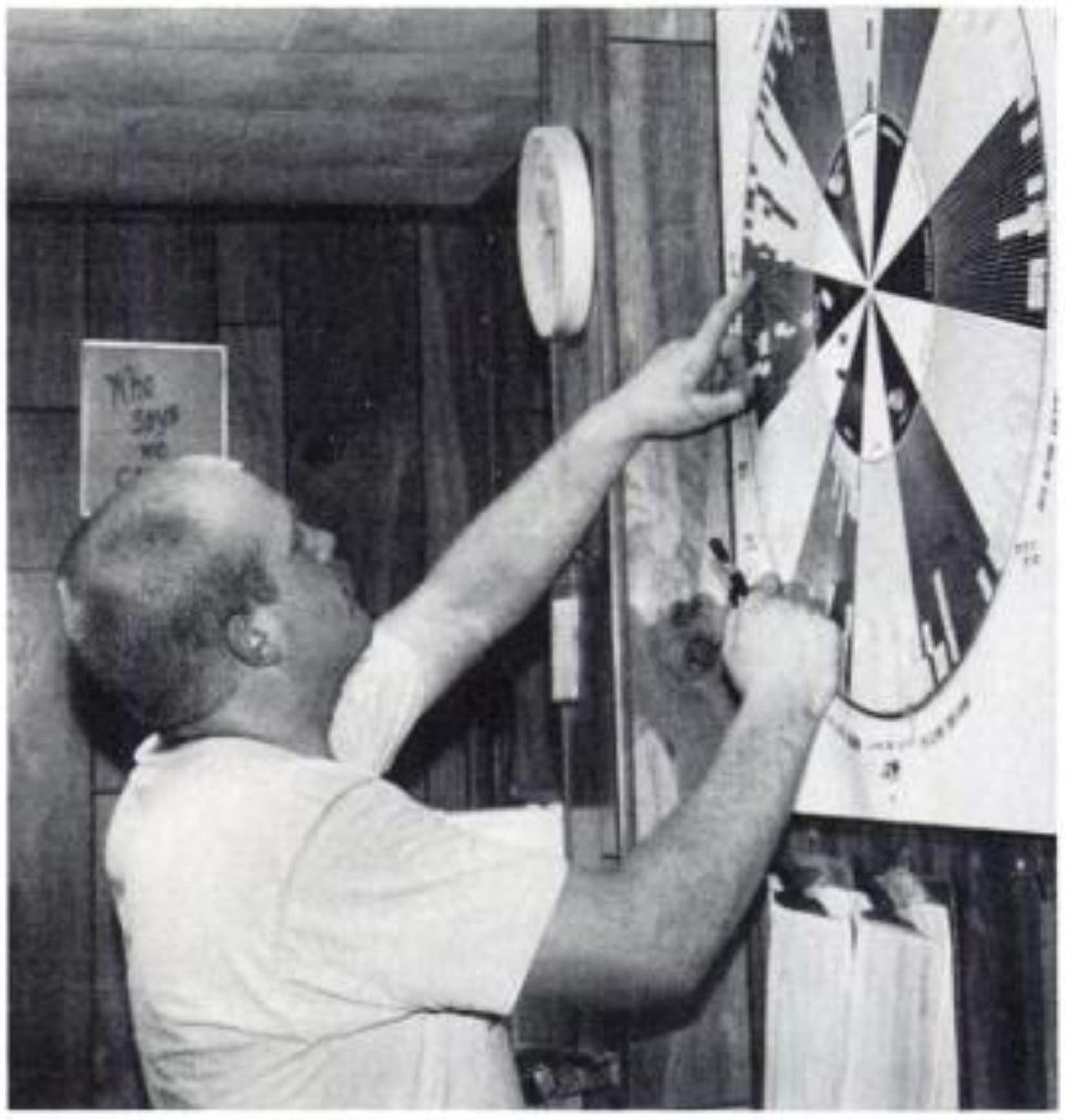
Even the most competent veterinarian must have an accurate history of the cow to provide accurate diagnosis and treatment for most infertile cows.

Reproductive health records also are needed in other phases of dairy management for maximum fertility. Accurate heat records, for example, provide a basis from which to predict the next date of heat. When anticipated, you stand a better chance of detecting it.

With accurate heat records, there are fewer supposedly silent heats because you know the approximate time to watch certain cows closely for heat. Accurate breeding records provide a basis for diagnosis of the cause of abortion, for timing in drying off the cow and for preparing a box stall for calving.

Keeping the records. There are two times when farmers wish they had better records. One is at the time they fill out income tax forms; the other is when the veterinarian starts to make a diagnosis of the cause of infertility.

In either case, the best way to keep records depends upon the farm and on the dairy producer. There are many successful ways of keeping herd health records. All successful systems have three characteristics in com-



BREEDING WHEELS help keep track of breeding, calving and drying off dates, along with other data.

cating she is to be bred at the next heat period. A glance at the tops of the folders in the file drawer shows which cows are to be bred within the next month.

Tabs of different colors may be used as a rapid reminder for such things as cows due to calve within one month, heifers to be vaccinated and cows diagnosed pregnant.

Computer systems are becoming more common for all types of farm record-keeping, particularly as the cost of computers drops. But like all systems, time must be set aside for accurate entry of up-to-date observations and information – the system only is as good as the information entered.

Usually, the best records are kept by one person only. Each of us has abbreviations and handwriting faults. Furthermore, when more than one person enters information on the records, important data often is not entered because one thought the other made the entry.

Action lists. The record system should be used to prepare "action lists" for routine herd management. These lists might include cows to breed, cows to dry off, cows due to freshen and cows due for a regular veterinary examination. If the record system is composed of folders with colored tabs, those cows with the same colored tabs would all be in one action list. Computerized systems can generate several varieties of action lists very quickly. Today, many Dairy Herd Improvement (DHI) record systems have options which provide special management lists on a regular basis.

Part of the management routine in a herd should be evaluation of the herd health records. Are they up to date? Are they providing the necessary information for the day-to-day management of the herd? Are the records useful for diagnosing fertility problems? If the answers to these questions are not "yes," the record system should be modified so that it becomes an effective management tool.

the opportunity to deposit semen in the vagina, in the cervix or any place in the uterus. The bull, of course, normally deposits the semen in the vagina next to the cervix. This location is satisfactory because he ejaculates about 10 billion sperm.

With artificial insemination, only about 15 to 20 million live sperm are used and **semen must be deposited in the uterus.** In A.I., do not deposit the semen in the vagina or cervix.

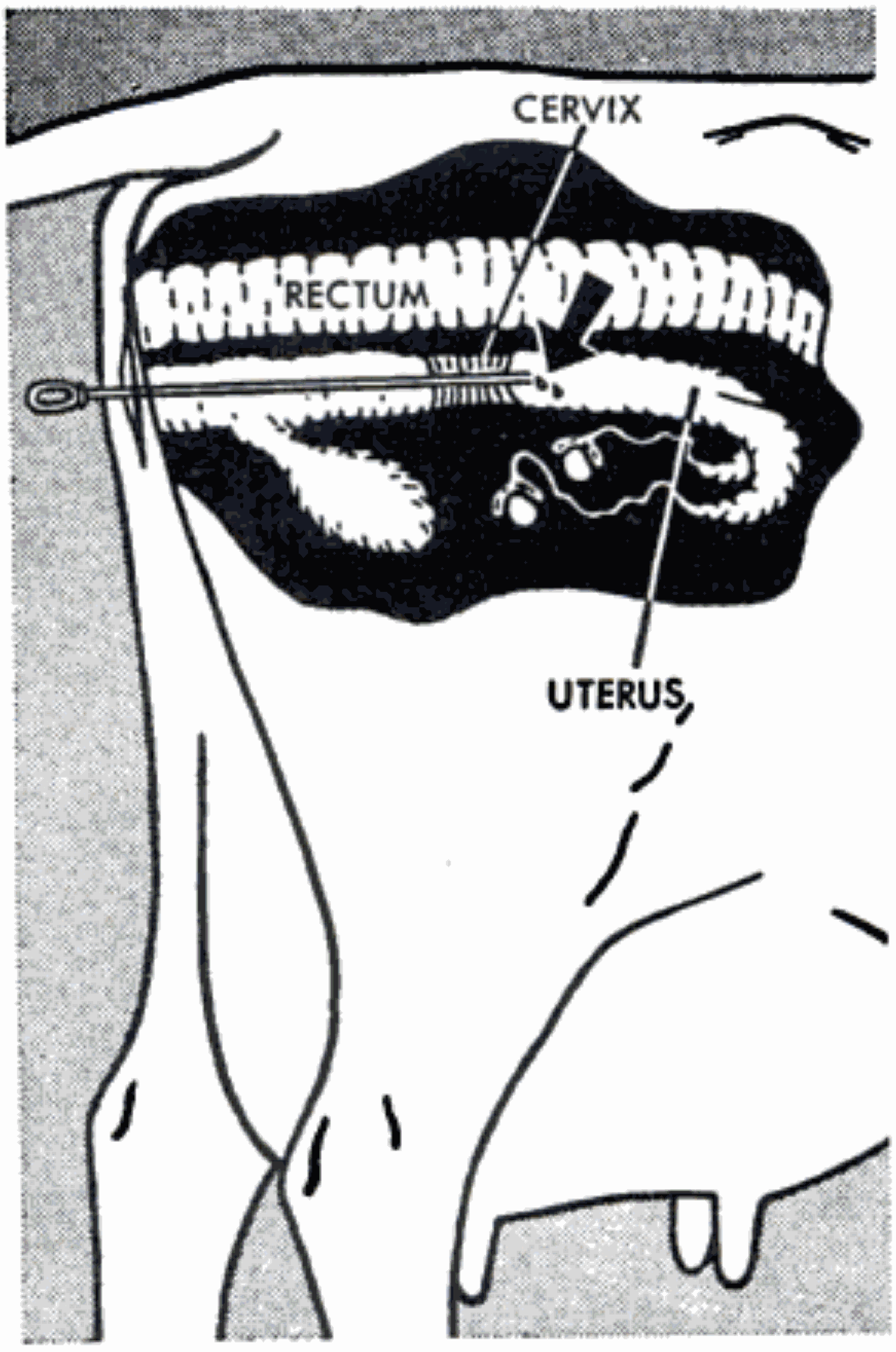
For the past 30 years, the uterine body has been the accepted site for depositing semen when cows are bred artificially. This recommendation has been based on the results of several fertility experiments which showed little difference in fertility when semen was deposited in the uterine horns, the uterine body or midcervix.

Everything considered, we recommend the procedure of inseminating the semen in the uterine body.

On repeat services, the recommendation also is to deposit semen in the uterine body. Approximately 5 percent of all pregnant cows show standing heat. If you suspect the cow is pregnant by a sticky feeling when passing the insemination rod, stop and deposit the semen in the anterior cervix. However, cervical deposition increases semen loss and lowers conception rates by about 25 percent.

When inseminating, guard against contamination of the catheter (inseminating tube) as it passes through the vulva. The vulva should be cleaned with a paper towel. Use the gloved hand inside the rectum to spread the vulva lips so the catheter end will remain clean.

Insert the catheter gently along the top of the vagina, guiding it with the hand in the rectum. Grasp the cervix firmly with the gloved hand and guide the catheter through it. With the forefinger, make sure the end of the catheter is **through the cervix into the uterine body. Expel the semen slowly.**



UTERINE BODY BREEDING. Semen is placed just past the cervix into the uterine body, which is approximately 5/8-inch in length.

Ideally, semen should be deposited in the uterine body to allow sperm transport up both uterine horns. Misplacement of semen decreases sperm numbers in one or both uterine horns, reducing the odds of fertilization and subsequent pregnancy rates.

Research using dye deposition has shown error rates for deposition of semen in the uterine body to be quite high (50 to 60 percent). More recently studies at Penn State University showed that only 37 percent of herd manager-owner inseminators and 41 percent of professional technicians deposited semen in the uterine body.

Because of these findings, the site of semen deposition has been reexamined with several studies evaluating conception rates obtained when semen was deposited in the uterine body versus conception when semen was deposited in each uterine horn. A Washington State University study evaluating horn breeding with about 4,000 breedings reported an approximate 10 percent improvement in conception following horn breeding.

Horn breeding is accomplished by depositing one-half of the semen dose in the right uterine horn and one-half in the left uterine horn. Movement into the horns should be discontinued immediately after any form of resistance has been encountered. No attempts should be made to deposit the semen at equal depth in the right and left side. The danger of uterine trauma, particularly when first starting to practice this technique, is minimal. However, it is important to discontinue forward movement of the insemination rod after resistance has been felt.

An important point is that the goal of horn breeding is not to put the semen deep in the uterus but to deposit the semen away from the cervix to eliminate cervical errors.

A likely explanation for the improved conception rates obtained with horn breeding is that no semen is deposited in the cervix. Cervical errors are common and, based on several studies, they account for over 20 percent of attempted uterine body depositions.

Remember that, regardless of

who inseminates the cow, the objectives of A.I. are unchanged. The important objectives for the dairyman are:

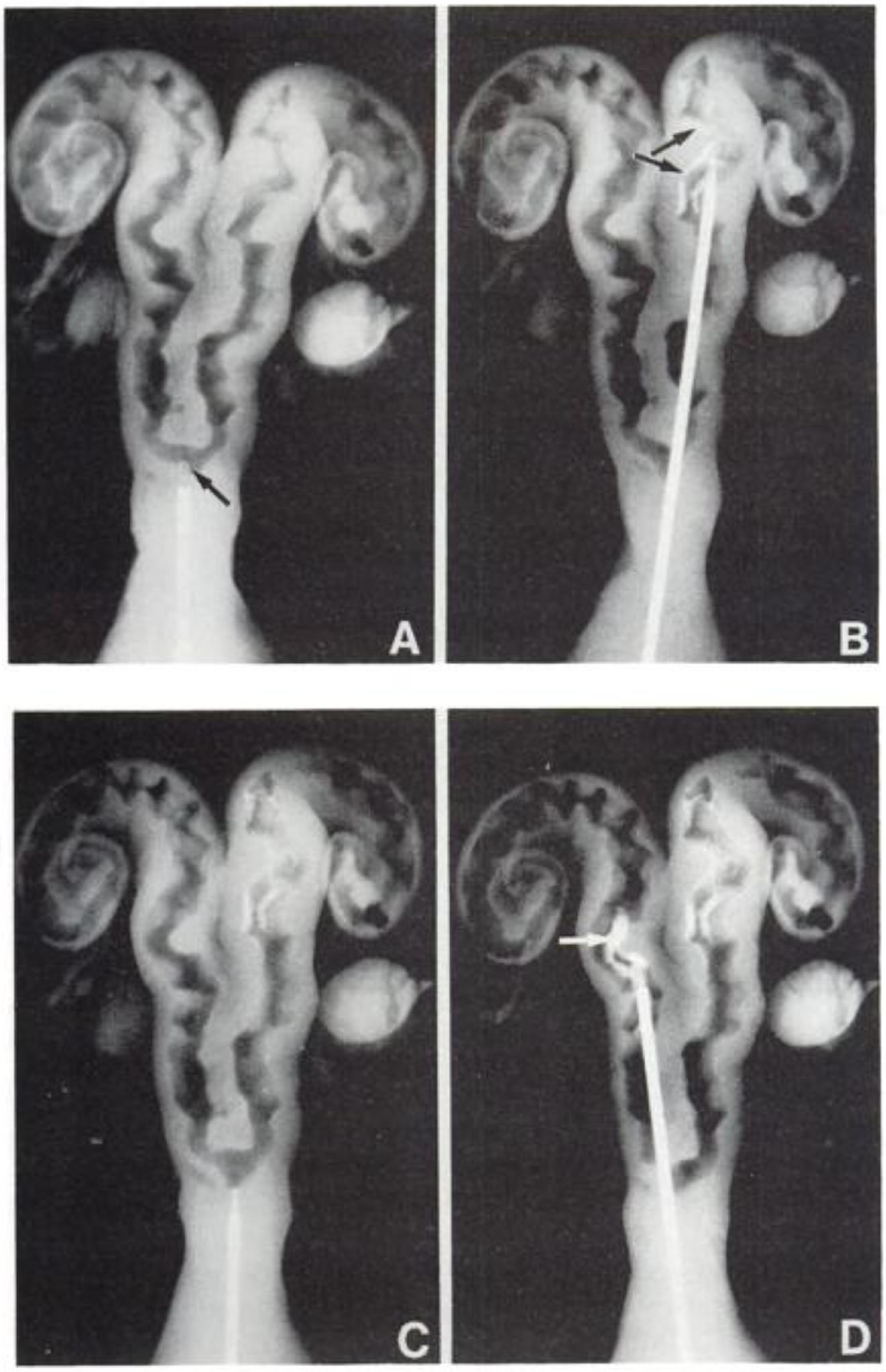
1. **Settle the cow;**
2. **Obtain calves from the best bulls;**
3. **Use disease-free semen;**
4. **Obtain the first three objectives at a reasonable cost.**

Good housekeeping. Prevent contamination of the insemination equipment with manure, water or soap. Even a small amount of sanitizing solution on the inseminating tube is sufficient to kill the sperm. Do not store inseminating tubes where they will collect dust, or leave the A.I. kit where it will become contaminated.

A survey of Michigan dairymen revealed that **cleanliness** ranked at the top of the list as the most important quality of an A.I. technician. Cleanliness ranked above conception rate and the technician's choice of sires to be used in the dairy producer's herd.

Unquestionably, dairy farmers expect more from the technician than from themselves in terms of cleanliness and sanitation.

Photos below demonstrate horn breeding



A SYRINGE TIP positioned at internal opening of cervix

B ONE-HALF OF semen deposited into right horn

C SYRINGE withdrawn into uterine body

D REMAINING semen deposited into left horn

times this check reveals that the herd problem is not as serious as first believed.

This step will identify "problem" cows and enable you to determine the average calving interval for the herd. A herd calving interval of 13 to 13.5 months is about right. Dairy producers should strive for a calving interval between 12 and 13 months to maximize annual milk production.

If the interval from conception last year to the first breeding this year is more than 12 months, it suggests:

- faulty heat observation
- weak or silent heats
- waiting too long after calving to start A.I. breeding, or
- uterine infection or a carry-over from difficult calving

If any of these appear as likely offenders, they might be alleviated by improved heat detection, early postpartum examinations or by seeing that the ration is properly balanced.

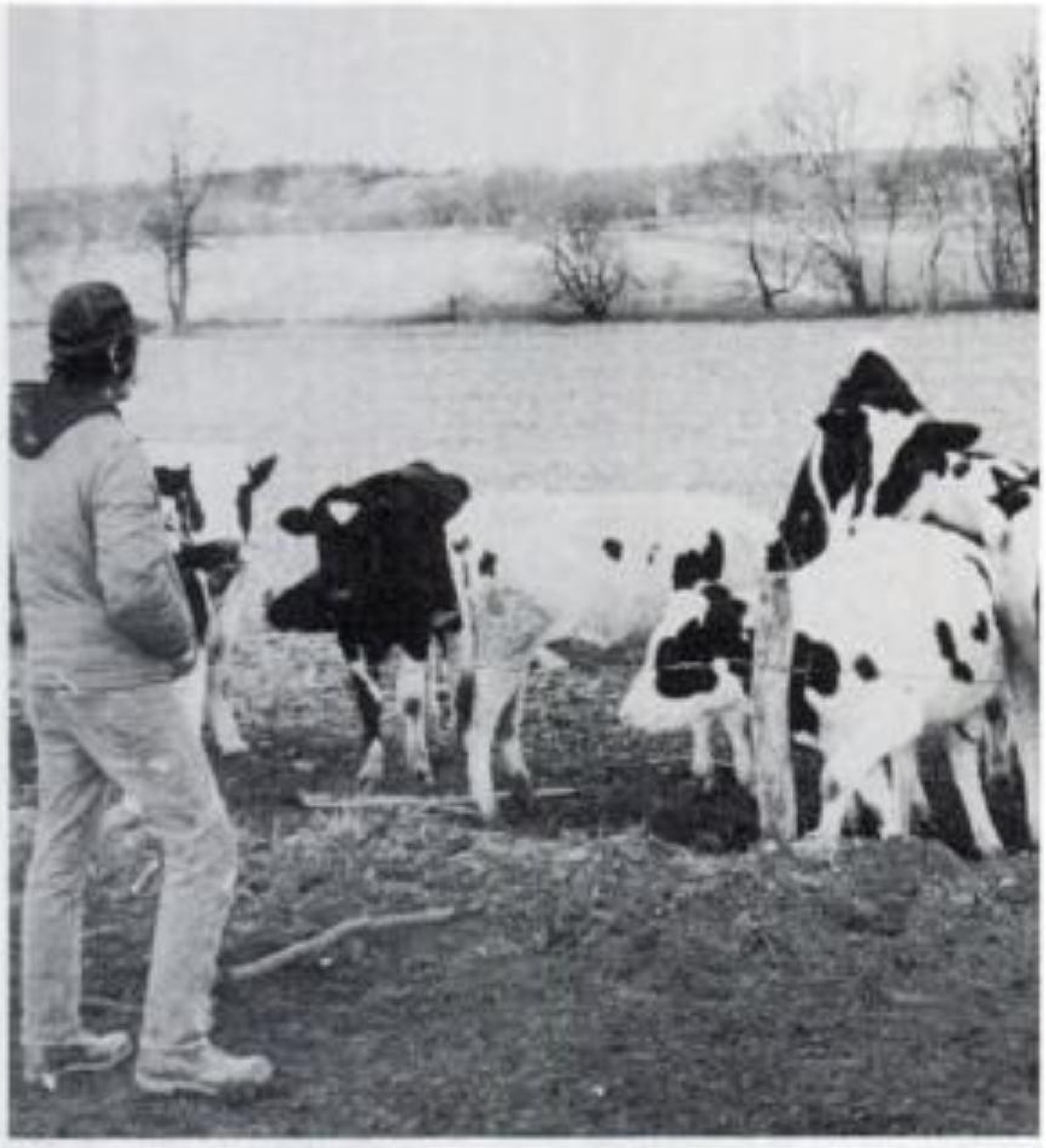
The service interval (time between inseminations) shown on the breeding records also gives valuable information. If the time between heat periods or breedings is shorter than the normal interval of 18 to 24 days, it suggests:

- cystic ovaries or
- faulty heat detection

Veterinary attention should confirm or eliminate the suspicion of cystic ovaries. If the service intervals are about 42 days, or range from 36 to 48 days, it suggests missed heat periods. And when service intervals are long and erratic, it may suggest uterine infection, improper heat detection or pregnancy loss by abortion. Keep in mind that routine use of prostaglandins will alter the service interval.

A bloody discharge about two days following heat is considered normal and can be a good clue as to whether cows are being bred during the heat period. Blood usually appears (if observed at all) about two days after the onset of standing heat. Therefore, it should follow breeding by 35 to 40 hours.

DHIA records help. Reproductive management information on DHIA records also can be extremely helpful. The "percent cows in milk" is the percent of time the cows in the herd were in milk during the past year.



OBSERVING HEIFERS AND COWS twice daily for signs of heat will improve reproductive efficiency.

To be consistent with a 12-month calving interval, this figure should be about 85 percent. If the figure is below 82 percent, it suggests prolonged calving intervals and may indicate a herd problem.

Additional reproduction information is listed on most DHIA reports. "Days open" is an excellent measure of reproductive efficiency that can be calculated from breeding records.

Average days open represents the interval between calving and the subsequent conception. The average for the herd should be no more than 105 to 110 days. With this measure, it is easy to spot "problem" cows.

When examining DHI records from high- and low-producing herds, one of the major differences in reproductive performance is that the best herds have significantly more cows inseminated before 60 or 120 days in milk than the poorest herds. This means that managers of higher producing herds are catching more cows in heat and inseminating them in a timely fashion after calving.

Heifers may be problem. Usually, heifers are managed separately from the cows. Because heifers frequently are neglected in herd management, their reproductive efficiency should be calculated separately from that for cows. Any difference in reproductive efficiency between heifers and cows may provide a clue to the source of trouble.

Dairy heifers always have higher conception rates than lactating cows (60 to 70 percent compared to 40 to 45 percent). If conception declines in both heifers and cows in the same herd when the same people are working with both groups of cattle, then A.I. procedures and technique should be reviewed, in addition to the heat detection program. If conception decreases in cows but not in heifers, then the source of the problem may be related to nutrition or to the season.

Too often, dairy producers pay little or no attention to heifers until the outset of the breeding season. Daily contact with the heifers facilitates estrus detection and provides breeding records.

The alert herd manager must be a first-class detective. A keen

Chapter 17

Controlling reproductive processes in dairy cattle

REPRODUCTION in cattle is a complicated process – many aspects are not well understood. Yet we have gained enough understanding about reproduction in the last 40 years so that today we are able to control the time of breeding in groups of animals, transfer embryos from outstanding donor cows to surrogate recipients, store embryos frozen for extended periods of time and control the time of calving. In this chapter we will describe the current state-of-the-art in some of these areas.

Synchronization of breeding. Estrus synchronization of heifers gives the option of using A.I. at a predetermined date. It permits insemination of the heifers at your convenience. It shortens the A.I. period and reduces the period of heat detection. A successful synchronization program depends heavily on good management and reproductively normal and regularly cycling animals. It also requires facilities for handling that are well-constructed and designed to minimize stress.

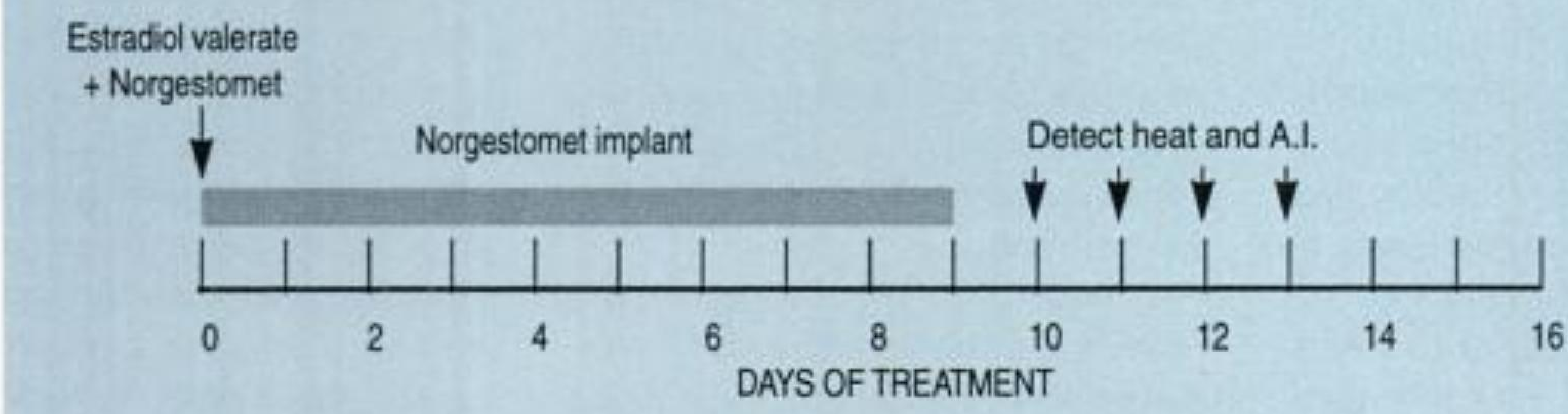
In the early 1950s, researchers in Wisconsin demonstrated that time of estrus could be controlled in cattle by administering progesterone injections for about 20 days. When progesterone was being given, cows were prevented from coming into heat. But 3 to 6 days after the progesterone treatment was stopped, cows came into heat as a group. This research demonstrated that the function of a cow's corpus luteum (CL) could be imitated by giving the hormone normally produced by the CL. Thus, controlling the time of heat really meant controlling the function of the CL.

Although this research demonstrated that the time of heat could be controlled, there were problems with the methods used. First, it was inconvenient to give each cow an injection of progesterone each day for 2 to 3 weeks. Second, fertility at the controlled heat was somewhat lower than normal.

During the 1960s, orally active synthetic progestogens were developed. These compounds were fed rather than injected, thus making the treatment more convenient. But the problem with reduced fertility remained. In the late '60s and early '70s it was found that the period of treatment with progestogens could be shortened by a few days if a small dose of estrogen was given on the first day of treatment. With this combination of an estrogen and a progestogen, synchrony of estrus was successful and fertility was higher than that observed when progestogens were given alone.

A commercially available product (Syncro-Mate-B®) for dairy heifers and beef cattle combines an ear implant which contains the synthetic progestin, norges-

Figure 1. Syncro-Mate-B® – Estrogen and progestin combination for heifers



tomet, and an injectable solution of norgestomet and a synthetic estrogen, estradiol valerate. The injection, which is given at the time the implant is inserted, causes regression of the CL in animals that have a CL present.

The progesterone implant prevents the development of a new CL in these animals and in animals that did not have a CL present when the estrogen injection was given. The implant is removed 9 days after insertion. Once the implant is removed, new cycles commence and animals express heat, beginning approximately 24 to 36 hours after implant removal. (Fig. 1).

In the early 1970s, researchers in the United States and Great Britain discovered that prostaglandin F2-*alpha* would cause premature regression of a cow's corpus luteum. Thus, time of estrus could be controlled in cows that had a functional CL. Any cow that was between day 6 and day 17 of a cycle at the time of prostaglandin treatment came in heat 2 to 5 days later. At any given time, about two-thirds of the cows in a group should have

Figure 2.

Double injection of prostaglandin

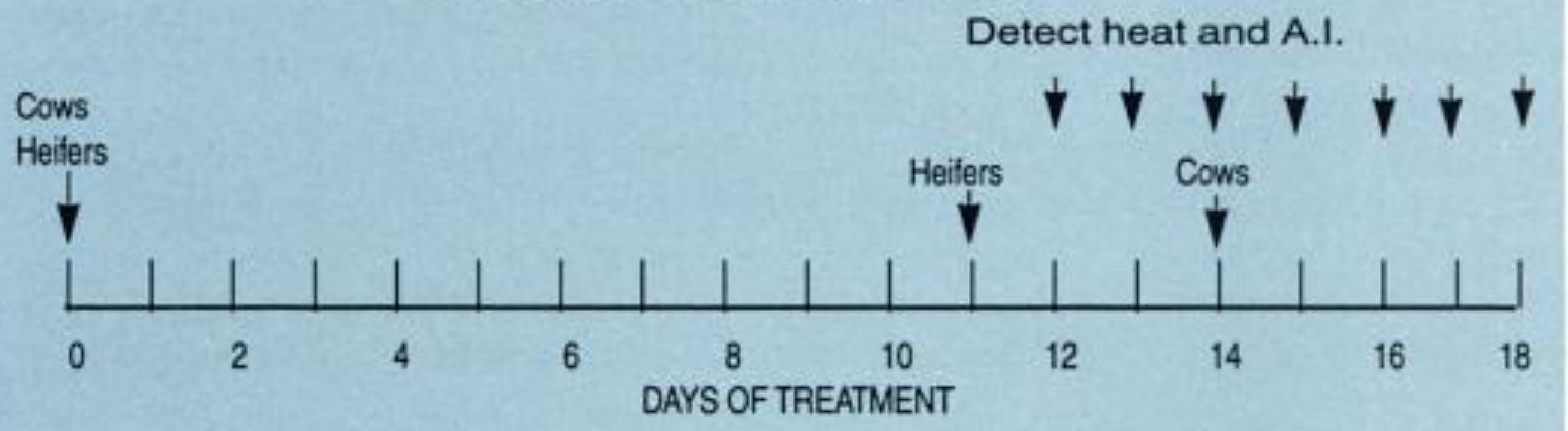


Figure 3.

Single injection of prostaglandin; check heat and A.I.; reinject nonresponders

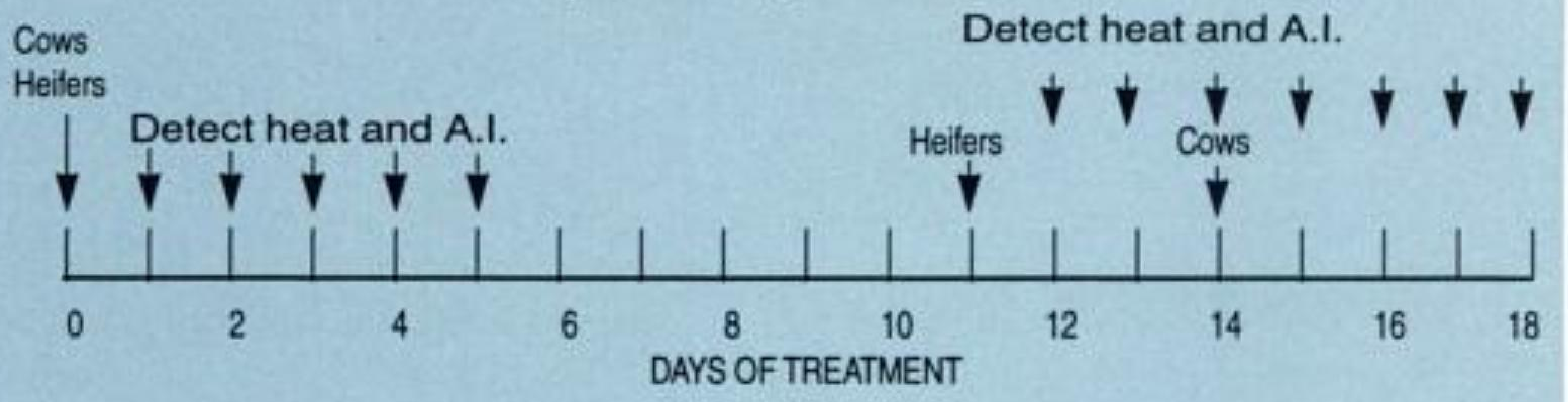
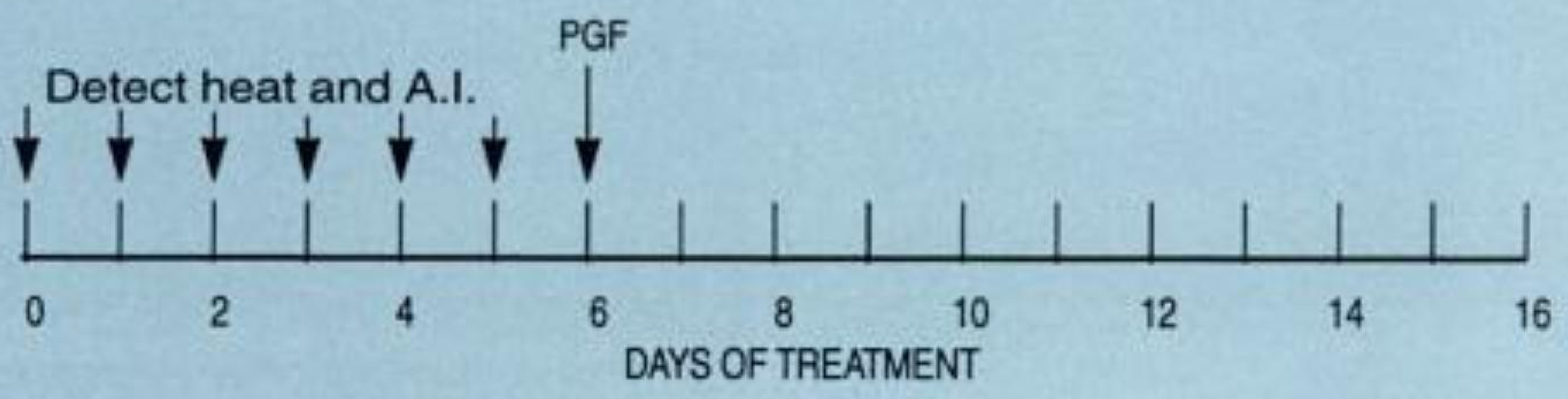


Figure 4.

Check heat for 6 days and inject prostaglandin



functional CL. So only about two-thirds of a group would be synchronized after a single injection of prostaglandin F2-*alpha*.

However, it was found that all the cows in a group would be responsive to a second injection of prostaglandin F2-*alpha* given 11 to 14 days after the first injection. Thus, the double-injection scheme was effective in synchronizing all the cows in a group. (Fig. 2).

Various synchronization programs utilizing prostaglandins have been developed for use under practical conditions. One such program designed to save money, labor and prostaglandin product is outlined: After the first injection, about 60 percent of the normally cycling animals will come into heat between 48 and 96 hours after injection. Animals detected in heat are inseminated about 12 hours after first seen standing to be mounted. Those animals not inseminated are injected a second time 11 to 14 days following the first injection and inseminated 12 hours after standing heat is detected. (Fig. 3).

This program can be modified to include heat detection for the six days prior to first prostaglandin injection to eliminate animals that would be coming into heat naturally and save drug costs of the overall program. (Fig. 4).

Another method involves using a combination of progestin and prostaglandin F2-*alpha*. Experimental intravaginal devices (PRID or CIDR) that release progesterone, which is absorbed through the vaginal wall, are being tested. In this combination, the progestin functions to hold those cows which are close to heat out of heat for a few days, and the prostaglandin triggers CL regression in those that have a CL. Usually the progestin is given for about 6 or 7 days and the prostaglandin is given one day before or on the day of withdrawal of progestin. Of all procedures tested, this method appears to give the best response in terms of both synchrony of estrus and fertility. As yet this procedure is not available commercially in the United States. (Fig. 5).

Another synchronization regimen combines the use of an oral progesterone (melengestrol acetate) and prostaglandin F2-*alpha*. Heifers are fed 0.5 mg of melengestrol acetate daily for two weeks preventing any heifers from coming into heat. Sixteen days after the last day of the oral progesterone supplementation, heifers are injected with a prostaglandin product and bred using normal heat signs and times. (Fig. 6).

Two procedures usually have been used to breed cattle that have been synchronized. One method involves a fixed-time A.I., where every treated animal is inseminated at a specified time

Figure 5.

Combination of progestin + prostaglandin for heifers

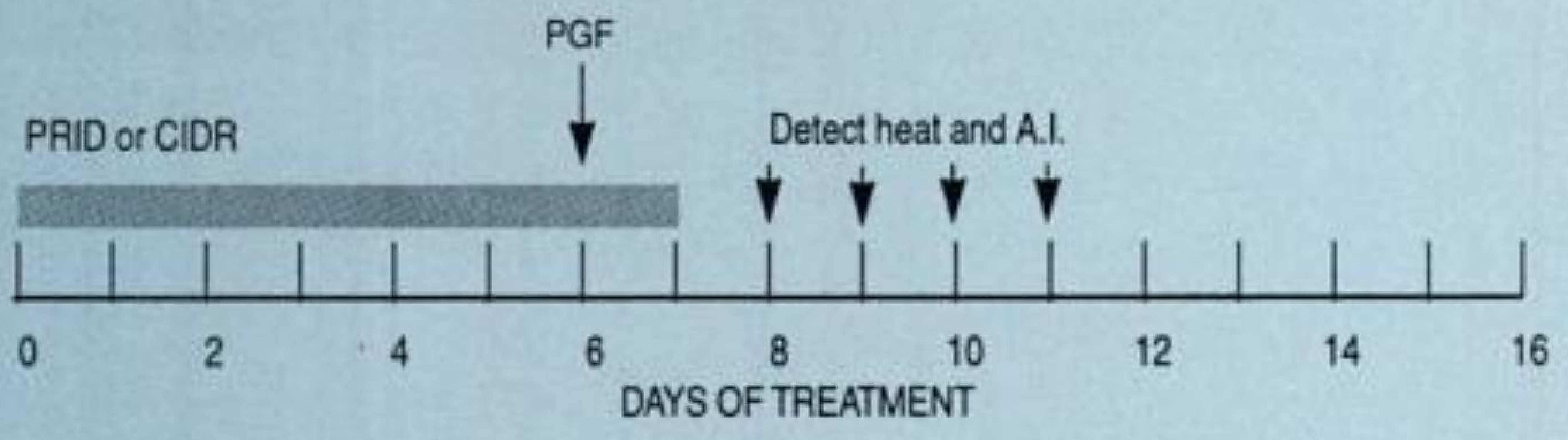
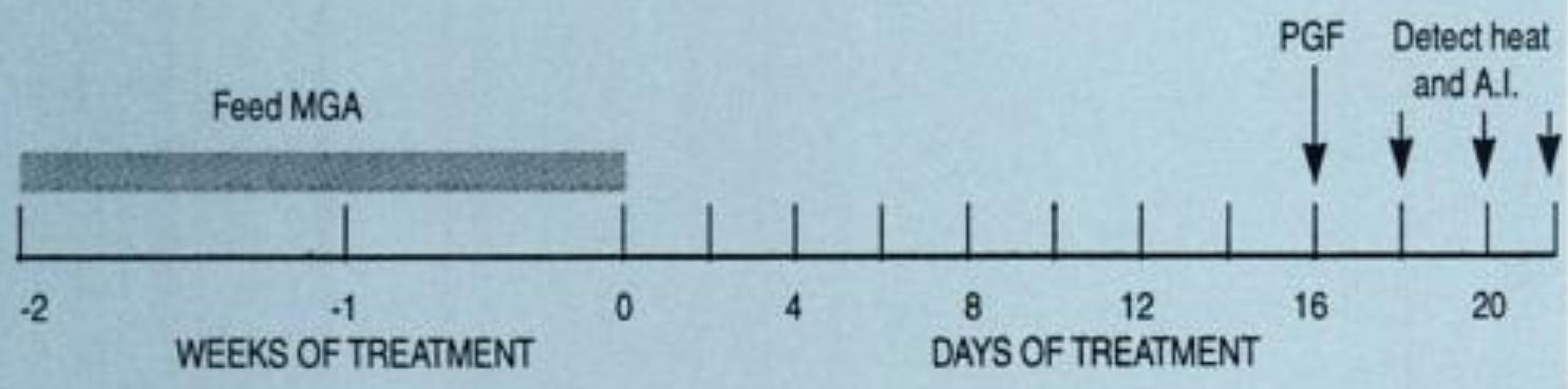


Figure 6.

Feeding melengestrol acetate (MGA) + injection of prostaglandin for heifers



after treatment. With this approach, there is no need to check cows for heat. But some inseminations may be given slightly earlier or later than is optimum because not all cows begin heat at the same time. The second approach involves breeding only cows detected in heat. This gives better timing for insemination, but some cows are not bred because they are not detected in heat.

A new method of controlling the estrous cycle involves the use of gonadotropin-releasing hormone (GnRH) and a prostaglandin in cows. In this program, cows can be inseminated based on the signs of heat (Fig. 7), or at one fixed time after prostaglandin (Fig. 8). A GnRH injection is given one week before the injection of prostaglandin. Cattle are then inseminated at the estrus following prostaglandin, or they are given a second injection of GnRH between 36 and 48 hours after prostaglandin and then inseminated 16 to 20 hours later without regard to signs of estrus (Fig. 8). The latter treatment in which inseminations occur at a fixed time after GnRH works well in cows but is **not** recommended for heifers.

An estrus synchronization program should be attempted only after consultation with your veterinarian or representative of your A.I. organization. Cattle must be cycling normally and in good body condition. Handling facilities should be adequate to avoid stressing cattle and personnel. An experienced A.I. technician should be on hand to do the inseminating, and two experienced technicians should rotate after about every tenth animal if a large group is to be bred.

An estrus synchronization program can be a valuable tool in a well-managed herd. It should not be attempted in a herd that has no prior experience with A.I. or in a herd where facilities are not adequate for handling groups of animals.

Embryo transfer. During the 1970s, major advances were made in developing procedures for embryo transfer in cattle. Today, several organizations offer embryo transfer services in the United States. And the techniques used today are much simpler than those used a few years ago.

Embryo transfer is still costly and thus should only be used to increase the number of offspring from cows that are genetically superior to their herdmates. With embryo transfer, the number of progeny produced from outstanding cows can be increased several-fold.

Embryo transfer involves two basic steps. The first step is superovulation of the donor cow. Donors are usually superovulat-

Figure 7.

Synchronized follicular growth,
CL regression and A.I.
with heat detection for cows

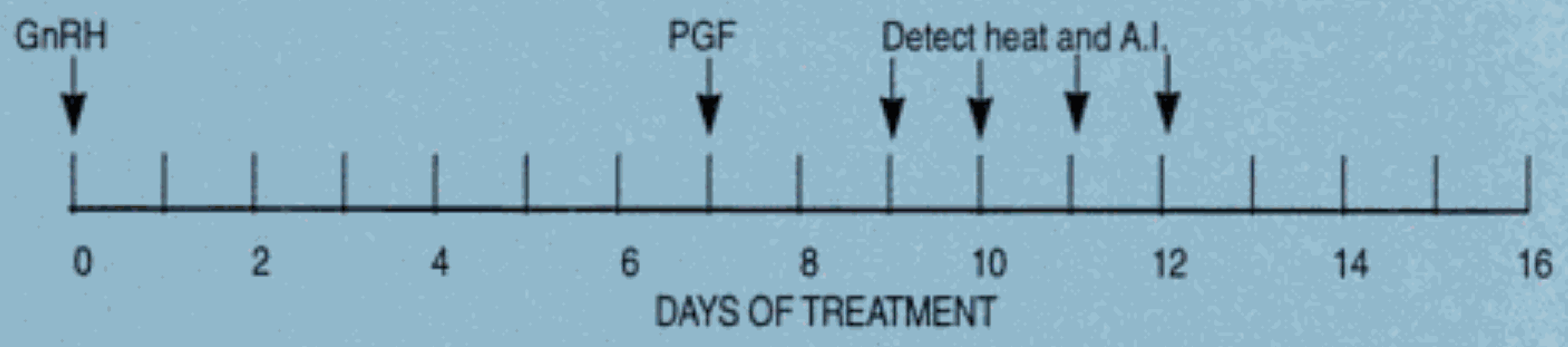
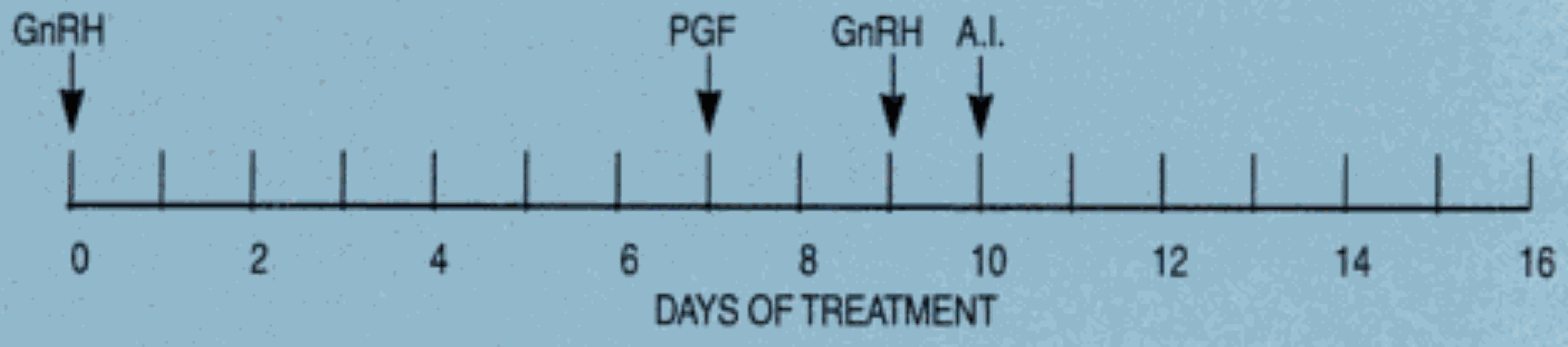


Figure 8.

Synchronized follicular growth,
CL regression and



ed by administering gonadotropins during the middle of a cycle. Once the donor cow has been stimulated, she is given prostaglandin F2-*alpha* to cause her to come into heat. At heat, she is usually inseminated one to three times. Insemination can be with semen from a single bull or with semen from two or more bulls. If more than one bull is used, the resulting calves have to be blood-typed to determine their sire.

The second step in embryo transfer involves recovery of the embryos from the donor cow followed by transfer of individual embryos to recipients that were in heat at the same time as the donor. Today, most embryos are flushed from the donor's uterus by a nonsurgical procedure. A catheter-type device (Foley catheter) is inserted into the uterus and a special medium is used to flush the embryos through the catheter into a collection vessel. The embryos are located in the medium with the aid of a low-powered microscope.

Once located, each normal-appearing embryo is transferred to a recipient. The embryo can be transferred through a small incision made in the recipient's flank. The embryo is deposited into the tip of the uterine horn adjacent to the ovary that contains the CL.

Today, most embryos are transferred nonsurgically by placing them into a semen straw and depositing them into the uterus (uterine horn adjacent to the ovary bearing the CL) in a manner similar to A.I. The nonsurgical procedure is easier, and pregnancy rates are equal to surgical procedure.

Although figures vary widely, the more successful embryo transfer organizations currently average about a 60 to 70 percent pregnancy rate.

Because of the costs involved, embryo transfer should be limited to outstanding cows. Best results are obtained when the donor cow is healthy and reproductively sound. Poorer results have usually been obtained when embryo transfer has been attempted on repeat-breeder cows.

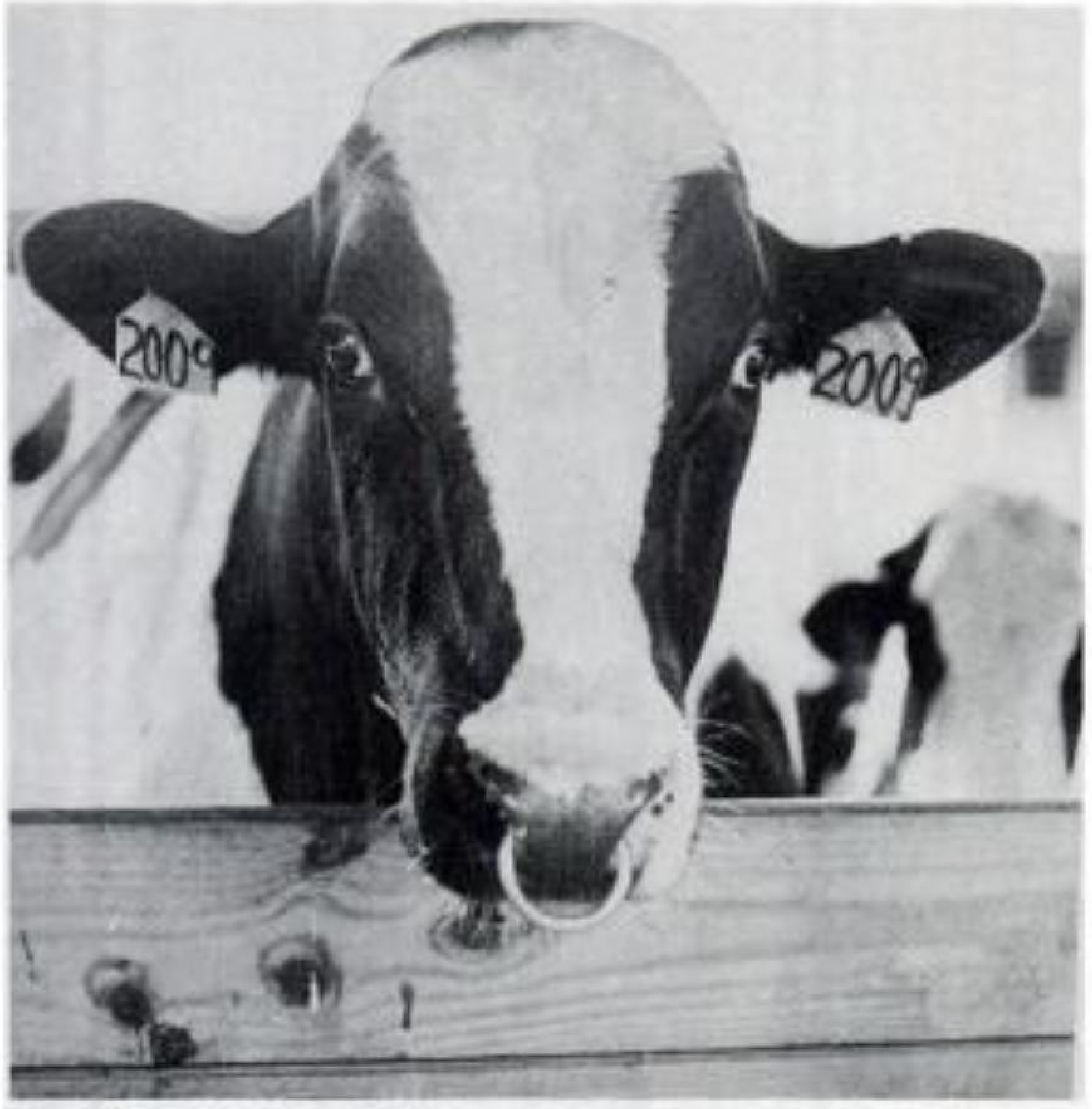
Breed associations must be notified of an intended embryo transfer. Also, their advance approval is necessary when using two or more bulls to inseminate the donor cow: This is to ensure that determining a calf's sire through blood-typing is feasible.

Freezing embryos. Techniques are now available for freezing and long-term storage of embryos. However, some problems still exist with these procedures. The major problem is that survival rate of embryos subjected

SUPEROVULATION AND EMBRYO TRANSFER from this donor cow produced five heifers and five bull calves.

Chapter 18

Using bulls on the farm



ON MANY of today's dairy farms, A.I. has essentially replaced the use of bulls. Still, many dairymen find it convenient to use bulls on certain cows and in certain situations where it is not possible to do a good job of heat detection. Proper use and management of bulls can result in improved reproductive performance of some herds, but improper use can mean disaster.

Bulls used on the farm should have outstanding pedigrees for production traits. Pedigrees can be evaluated by use of a simple index called "Parent Average", or "Estimated Transmitting Ability". A dairy producer needs the most recent Predicted Transmitting Ability (PTA) values from USDA on the sire and dam of a prospective herd bull to calculate parent average. Parent average for a single trait like milk production would be calculated by averaging PTA for milk from the sire and the dam of the bull.

Standards for acceptable value for a herd bull should increase through the years due to genetic trend. Holstein and Jersey breeds currently are improving by at least 150 lbs. per year in PTA. Sires of herd bulls should be among the very best A.I. sires available, with a Rank Percentile at least above 80 and preferably above 90.

Dams of herd bulls should qualify or be very close to qualifying for USDA "Elite Cow" status. Breed organizations can provide you with current Elite Cow standards of PTA MFP$.

Remember that the herd bull can quickly become the most influential sire used in a herd breeding program. His pedigree is extremely important, but his best role for genetic improvement would be the smallest possible role compared to good A.I. sires.

Growing the bull. Bull calves can be fed and housed with heifers when they are young. But it is a good practice to provide separate housing for bulls over 6 months of age. Feed the bull to keep him growing steadily without fattening. The nutrient requirements for bull calves are similar to those for heifers. Provide bull calves with a well-balanced ration that contains appropriate amounts of minerals and vitamins.

Make sure that the bull has plenty of opportunity for exercise. Don't put the bull in a small, poorly bedded stall in the corner of a barn and forget about him. Pay close attention to the bull's feet. If the feet become overgrown, have them trimmed properly. Poor development of feet and legs can cause problems later on. Also, make sure that any parasites that might affect his performance are controlled.

Most bulls will reach puberty and be able to breed heifers by 12 to 15 months of age. However, bulls should be older than this before they are used regularly on mature cows.

Health exam. Before a bull is put into use, he should have a breeding soundness exam conducted by a veterinarian. This exam should include health tests for any diseases that he may transmit to cows as well as a thorough examination of his reproductive system. A semen sample should be collected and evaluated. The bull should be allowed to breed a cow in heat and observed to make sure that he performs correctly.

The breeding soundness exam will help identify bulls that may be poor breeders or that may have some anatomical defect in the reproductive system. The exam will not indicate whether the bull will have high, normal or low fertility.

Using the bull. Once the bull is ready for use in breeding, he can be used in two ways. He may be run with a group of animals or he may be housed individually and used to breed selected cows put into his pen. The first method reduces the amount of time required for heat detection. However, when a bull runs with a group of animals, he still needs to be observed regularly.

When a bull is to be used to

ISBN 0-932147-27-5